THE MODERN PLUMBER & SANITARY ENGINEER

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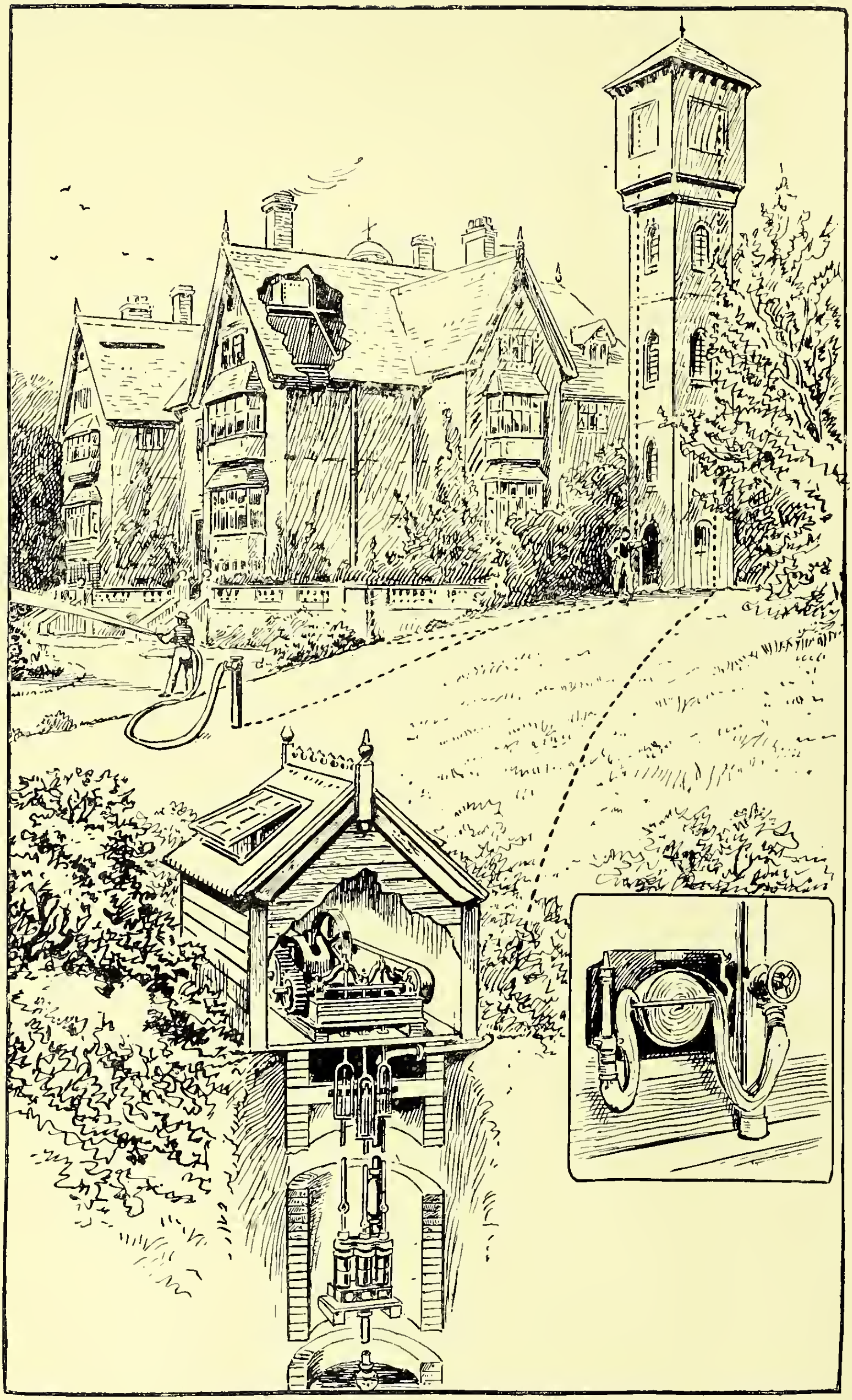
AND SANITARY ENGINEER



THE WATER SUPPLY TO A COUNTRY MANSION

Showing well and pump in foreground, tower containing large storage tank, subsidiary tank in house, and hydrant in garden; the inset shows a fire-hose and hydrant fitted inside the house.

THE MODERN PLUMBER AND SANITARY ENGINEER

TREATING OF PLUMBING, SANITARY WORK, VENTILATION, HEATING (ELECTRIC AND OTHER), HOT-WATER SERVICES, GAS-FITTING, ELECTRIC LIGHTING, BELL-WORK, GLAZING, &c.

BY SIXTEEN SPECIALIST CONTRIBUTORS

UNDER THE EDITORSHIP OF

G. LISTER SUTCLIFFE

A.R.I.B.A., M.R.S.I.

Editor of "The Principles and Practice of Modern House Construction", &c.

WITH APPENDICES OF
TABLES, MEMORANDA, MENSURATION, ETC.

ILLUSTRATED BY ABOUT ELEVEN HUNDRED FIGURES IN THE TEXT AND ABOUT FIFTY PLATES, MANY OF THEM IN COLOUR

DIVISIONAL-VOL. VI

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BY

J. D. SOMERVILLE

SECTION XIII.—GASFITTING

CHAPTER I

COAL GAS

Composition.—When coal gas is first distilled from coal, and after it has been cooled in the first stage of its purification, its composition is approximately as follows:—[1]

Hydrogen	from 42	to 53	per cent by volume.
Methane (marsh gas) ...	„ 32	„ 39	„ „
Carbon monoxide ...	„ 3	„ 10	„ „
Hydrocarbons, gaseous ...	„ 2·5	„ 4·5	„ „
Light condensable vapours	„ ·5	„ 1·2	„ „
Carbon dioxide (carbonic acid)	„ 1·1	„ 1·8	„ „
Nitrogen	„ 1·0	„ 5·0	„ „
Hydrogen sulphide ...	„ 1·0	„ 2·0	„ „
Ammonia	„ ·5	„ ·95	„ „
Cyanogen	„ ·05	„ ·12	„ „
Carbon disulphide ...	„ ·02	„ ·035	„ „
Naphthalene	„ ·005	„ ·015	„ „

When gas has reached the state in which it is ready to be supplied to the consumer, its composition is approximately as follows:—

Hydrogen	47·99	per cent by volume.
Methane (marsh gas)	37·64	„ „
Carbon monoxide	3·75	„ „
Heavy hydrocarbons	4·41	„ „
Carbon dioxide	—	
Oxygen	·26	„ „
Nitrogen	5·95	„ „
	100·00	

Hydrogen is the largest component of common coal gas, and is the lightest of all known bodies, having a specific gravity (at 30 in. pressure and 60° F.) of ·0692; 100 cu. in. weigh only 2·15 gr. The quantity of this constituent of coal gas is subject to variation, depending principally upon the amount of moisture contained in the coal distilled and on the

[1] These figures are given by Mr. W. J. A. Butterfield in his work on *Gas Manufacture*.

temperature of the distillation. The proportion sometimes amounts to 50 per cent.

Methane or marsh gas is also always found in coal gas, and is known in colliery districts, where it is met with in the coal mines, as *fire damp*. It is tasteless and colourless, with a specific gravity of ·553, and 100 cu. in. weigh 17·15 gr. This gas and hydrogen are the two principal constituents of coal gas.

Naphthalene (the most troublesome constituent of coal gas) is a solid body, which is converted into vapour at a temperature of about 170° to 180° F. The vapour adds greatly to the illuminating power of the gas; but when the temperature of the gas is reduced in the mains and services, the vapour condenses and is deposited therein in a solid form, causing much trouble at times to clear away.

Methods of Increasing the Illuminating Power.—In many towns in the provinces, owing to the regulations of the local authorities, the gas supplied to the public must be of a certain illuminating power, and one of the largest companies in London is supplying its gas under similar restrictions. Now, if gas is distilled from coal at a very high temperature, a greater volume per ton of coal is obtained, but it is of lower illuminating power than that required by the regulations mentioned; therefore some addition must be made to it in order to raise it to the specified standard. There are two usual methods of doing this—(1) by the addition of carburetted water gas or oil gas of high illuminating value, and (2) by the addition of oil vapours.

Carburetted water gas is obtained as the result of separating water into its component parts—hydrogen and oxygen—by passing a volume of steam under pressure through a mass of incandescent coke at a temperature of about 1000° C. (1832° F.). The oxygen combines with the coke and forms carbon monoxide, and the hydrogen passes along through a series of apparatus in which it comes in contact with a stream of oil vapour, which has been raised to much the same temperature, and with which the hydrogen thoroughly combines. The combined gases then pass through a superheating chamber, where, owing to the temperature, the oil vapour and the hydrogen become a fixed gas of (say) twenty-six candle power, and approximately the following composition:—

Hydrogen	35·17	per cent	by volume.
Methane	13·58	,,	,,
Carbon monoxide	33·92	,,	,,
Hydrocarbons	12·83	,,	,,
Carbon dioxide	1·54	,,	,,
Nitrogen	1·76	,,	,,

The oil used for the manufacture of carburetted water gas is usually Russian solar distillate (a distillate of petroleum) or Scotch shale oil.

Water gas ought not to be used exclusively for illuminating purposes on account of the amount of the very poisonous carbon monoxide it contains. It has been stated that ·1 per cent of carburetted water gas renders the air of a room injurious, while 1 per cent makes it fatal; there-

fore only a very small percentage of carburetted water gas is added to the common coal gas to increase its illuminating value. The Parliamentary Committee which considered the subject of the admixture of carburetted water gas with common coal gas fixed the maximum as just over 16 per cent.

Oil Vapour.—The other usual method of raising the illuminating power of common coal gas is by the addition of oil vapours. *Benzol*, or a petroleum distillate called *carburene*, or another known as *gasolene*, is used. Commercial 90-per-cent benzol containing about 70 per cent benzene and 25 per cent toluene has a boiling-point of between 82° and 112° C. (179·6° and 234° F.), and a specific gravity of from ·882 to ·885. Carburene has a boiling-point of about 70° C. (158° F.), and a specific gravity of ·68. Gasolene has a boiling-point of about 40° C. (104° F.), and a specific gravity of about ·70.

The process of vaporizing the oils is much the same in each case. They are placed in a chamber surrounded by steam, and the vapour formed by this heat is conducted by suitable means to the gas mains that supply the district. The amount of any of the oils used is about 1 gal. for one candle increase to every 10,300 cu. ft. of gas.

CHAPTER II

GASFITTERS' TOOLS

Stocks and Dies.—Each length of wrought-iron gas pipe is provided with an external thread at each end extending backwards for about 1 in., and on one of these ends a socket, having an internal thread corresponding to that already on the length of pipe, is screwed. Thus, each length of pipe is delivered from the manufacturer ready to be screwed to another to make as long a "run" of pipe as is required. The thread on the end of the pipe unprotected by the socket is often damaged by careless stacking, or by an accidental knock in transit from the maker's works, so that much difficulty is experienced when attempting to screw one length into another. In order to obviate this, a tool termed a *die stock*[1] is made, containing a screw die, which is easily adjusted to suit pipes of different diameters, and which with one or two turns on the pipe corrects all the damage that has been done.

The stocks and dies made for the larger sizes of pipes—*i.e.* from $\frac{5}{8}$ to 2 in.—usually have to be changed for each size; but for the smaller sizes ($\frac{1}{8}$ in., $\frac{1}{4}$ in., $\frac{3}{8}$ in., and $\frac{1}{2}$ in.) die stocks are made containing dies for each size in one setting, thus making a most handy tool. Accompanying each size of die are taps for making threads in holes (drilled for the purpose), and usually three in number for each size of hole, namely, *a taper tap* (or commencing tap), which starts the impression of the thread; *the second tap*, which increases the impression; and *the plug tap*, which completes the thread, and makes it ready to receive the length of pipe to be screwed into

[1] See fig. 37, p. 54, Vol. I

it. There are also some taps made by which all three operations can be performed with the one instrument; but much care has to be exercised, when using them, not to go too quickly, or the taps are likely to be ruined.

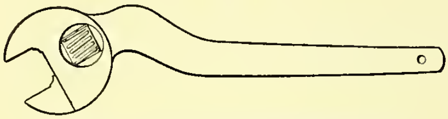


Fig. 954.—The Clyburn Shifting Spanner

The Spanner.—The most useful form of spanner for a workman to carry with him is *the shifting spanner*, such as the well-known Clyburn (fig. 954). This is fitted with a movable jaw to take the various sizes of nuts, the jaw being operated by means of a milled screw attached to the head of the spanner.

The old-fashioned gas tongs (fig. 955) are composed of two pieces of iron. When the curved portion has been placed around the piece of pipe to be screwed, the under lip grips the pipe on the handles being squeezed together. This description of tongs is in everyday use, but is not altogether satisfactory, as the part which grips the pipe soon becomes worn and requires constant attention; and, further, it is necessary that several sizes of tongs be carried to fit the various pipes met with, as each size of pipe necessitates the use of two pairs of tongs, one pair for the barrel part of the pipe, and one for the socket, which of course is larger than the barrel. The size of tongs used for the socket of (say) a piece of $\frac{1}{2}$-in. pipe is the same as it is necessary to use on the barrel of a piece of pipe of $\frac{3}{4}$-in. diameter, and the $\frac{3}{4}$-in. socket tongs fit the 1-in. barrel, and so on.

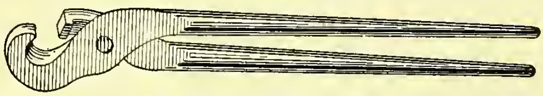


Fig. 955.—Ordinary Gasfitters' Tongs

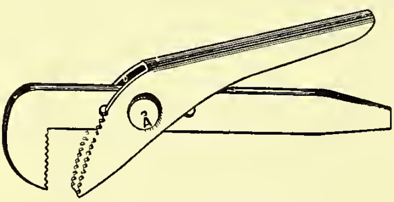


Fig. 956.—Pipe Wrench

The pipe wrench (fig. 956) is more useful, as it is adaptable to many sizes of barrels and sockets. The movable portion is altered and held in position, as the size of the pipe requires, by the bolt A, which can be taken out at will.

Another excellent tool, by which great purchase can be obtained upon stiff pipes, is Brock's patent **chain tongs or wrench** (fig. 957). This may be considered the best tool for all-round work. The chain grips the pipe against the hardened steel teeth of the jaw of the tool. The jaw is of such a degree of hardness that, when the teeth are worn, fresh teeth can be made with a file.

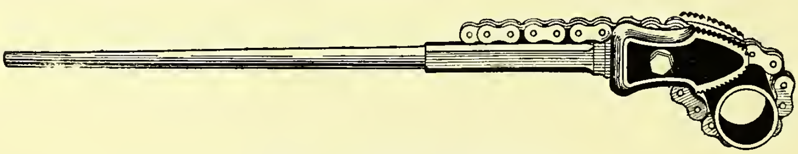


Fig. 957.—Vulcan Chain Pipe Wrench

It is often necessary to cut a length of pipe to complete a circuit, or

make a connection to a fitting, and for this purpose a **pipe-cutter**[1] is required. A thread can be cut on the end by means of the stock and die, or, if the pipe is large, by a screwing machine[2].

The pipe vice is an arrangement for holding firmly the piece of pipe that is to be cut or screwed, so that it will not turn when the stock and dies or the cutting tool is used. The vice shown in fig. 958 has two pillars, on which a cross bar moves up and down. By means of the two nuts the toothed jaw below the cross bar can be pressed down to grip the pipe tightly.[3]

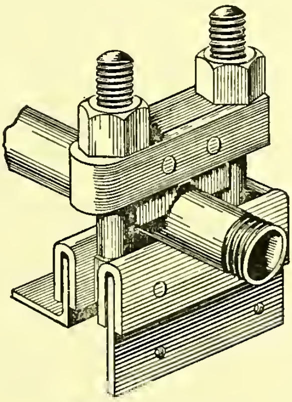


Fig. 958.—Pipe Vice

CHAPTER III

PIPES, COCKS, BYPASS TAPS, AND SIPHONS

Gas pipes are of two kinds: wrought iron and a composition of lead, tin, zinc, &c. The latter (usually known as "compo" pipe) is so little used at the present time, except for pipes of small size, and for making the junction between the end of the supply from the main and the meter (to which particular reference will be made later), that little need be said about it. It should not be used for any size beyond (say) $\frac{3}{8}$ in., and should never be hidden from sight, as if it is buried in the plaster a nail is easily driven into it, causing an escape of gas, which cannot be stopped without damaging the plaster and the decorations.

Size of Pipes.—Before commencing to lay a service from the street to a dwelling house, it is necessary to consider in the first place how much gas will be required. This can easily be ascertained, as several tables giving the rate at which coal gas flows through pipes of varying sizes have from time to time been compiled from experiments. For the present purpose that recently given in Mr. W. Grafton's useful book on *Practical Gasfitting* will be most suitable.

Flow of Gas at 1-inch Pressure through W. I. Pipes per Hour.

Length of Pipe in Yards.	15	25	50	75	100
Diameter of Pipe in In.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.	Cu. Ft.
$\frac{1}{2}$	44	40	37	32	27
$\frac{3}{4}$	114	108	95	78	67
1	223	212	187	152	128
$1\frac{1}{4}$	388	368	323	263	222
$1\frac{1}{2}$	613	590	507	413	345
2	1280	1225	1070	880	750
$2\frac{1}{2}$	2220	2115	1820	1520	1270

[1] See fig. 36, p. 53, Vol. I. [2] See fig. 34, p. 51, Vol. I. [3] Another kind is shown in fig. 35, p. 52, Vol. I

By dividing the number of cubic feet by the size of the burner that is to be used, the number of burners which any particular size and length of pipe will supply may be found.

It should, however, be noted, that the pressure under which gas is supplied always exceeds 1 in., and the amount of gas flowing through the pipe is increased directly as the square root of the pressure and reduced inversely as the square root of the length of the pipe. For example, with four times the pressure the quantity supplied is about doubled, whilst with four times the length of pipe the supply is about halved. From the above table it will be seen that coal gas under a pressure of 1 in. will flow through a 1-in. pipe 15 yd. long at the rate of 223 cu. ft. per hour; but should this pipe be 50 yd. long the flow is reduced to about 121 cu. ft. per hour.

The following useful table, also from Mr. Grafton's work, shows the maximum length of pipe which should be used in any particular diameter for the specified number of lights.

Internal Diameter of Tubing. Inches.	Greatest Length. Feet.	Number of Lights Allowable.
$\frac{3}{8}$	20	3
$\frac{1}{2}$	30	4
$\frac{5}{8}$	40	10
$\frac{3}{4}$	50	15
1	60	25
$1\frac{1}{4}$	90	40
$1\frac{1}{2}$	120	70
2	160	130

Connections to Mains.—Having decided the proper size of pipe to be laid down, and ascertained the position of the gas main, the trench is dug and the main drilled for the connection. This last is done by a drilling apparatus, which is placed round the main, and is of such a kind that it drills the hole required and taps the screw thread ready to receive the pipe, allowing very little gas to escape during the operation. When laying a service to a building, a fall should be given to the pipes in the direction of the gas main, as by doing this any moisture that may be deposited will run back to the main by gravitation. The supply to the dwelling is run from the place where the meter is to be fixed back toward the main, care being taken that every joint has a good coating of red-lead paint or other approved jointing material. A connector (No. 9, fig. 959) is screwed into the hole drilled in the main, ready to meet the supply when this is brought up to it. This "connector" is a short piece of pipe of the same diameter as the supply pipe, but which has a thread upon one end of it sufficiently long to allow of a back nut (No. 15, fig. 959) and a socket (No. 18) being screwed back upon it so that about two threads of the screw protrude. The connector is made of such a length that the end of the supply pipe just butts against it; the socket is then screwed forward over the end of the supply pipe and a piece of leaded yarn wound round behind the socket,

and the back nut is screwed up behind it, making a strong tight joint. Fig. 959 shows the ordinary wrought-iron gas barrel and fittings.

On the end of the service to the house, where the meter is to be fixed, **a main cock** fitted with a cap and lining (fig. 960) or a union (fig. 961) is screwed for the reception of a piece of lead pipe which is taken from it to the meter inlet. The lead pipe is fixed to the lining of the union

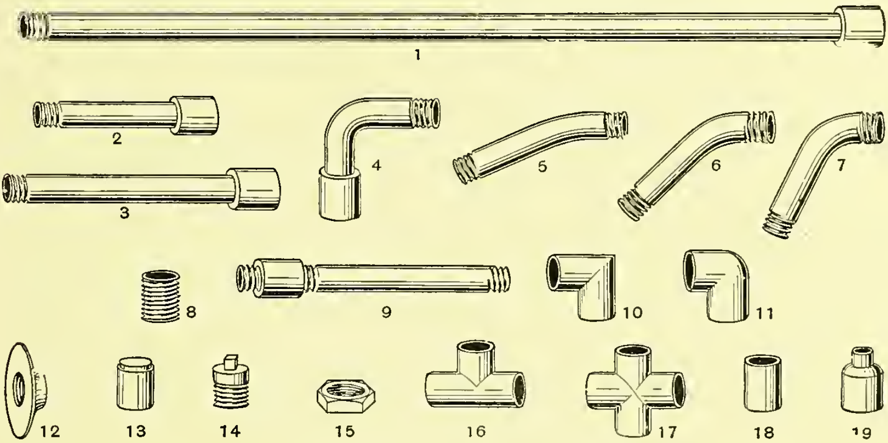


Fig. 959.—Wrought-iron Gas Barrel and Fittings

1, Barrel 2 ft. and upwards in length; 2, Pieces 3 in. to 11½ in. in length; 3, Pieces 12 in. to 23½ in. in length; 4, Bend; 5–7, Springs; 8, Nipple; 9, Long Screw or Connector; 10, Square Elbow; 11, Round Elbow; 12, Flange; 13, Cap; 14, Plug; 15, Back Nut; 16, Tee; 17, Cross; 18, Socket; 19, Diminished Socket.

by a blown lead joint, and is taken thence to the meter with an easy bend. The length of this piece of pipe is about 2 ft., and lead is used because it can be bent a little when the meter has to be taken away for examination, thus saving the disturbance of the main supply.

The house supply pipe from the meter should be of the same size on the main floor as that entering the building, so that any stoves or fires that may be supplied from it will be sure of having sufficient gas. On the upper floors the size may be decreased. This only applies to stove and fire supply pipes, and not to those for lighting purposes; these latter should be on a different service, so that there will be no chance of their failure when the fires and stoves are in use. Their complete independence can be ensured by branching them from a second supply run straight from the meter.

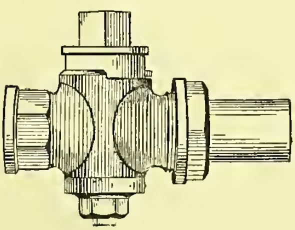


Fig. 960.—Main Cock with Cap and Lining

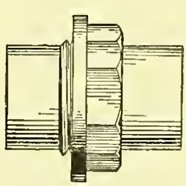


Fig. 961.—Union

The size of branch pipes for wall brackets need not be more than ¼ in. for each bracket, but should not be less if a plentiful supply of gas is to be ensured. The branches are taken off the principal lighting supply by means of T pieces having the through bore of the same diameter as the large pipe, but the branch outlet smaller.

In the case of **large rooms and halls**, it is generally necessary to arrange the pipes, &c., in such a way that part of the fittings can be cut off if all are not required at the same time; this is done by taking the main supply to a box in some suitable place, and from this running separate services to the parts of the building requiring them, each service having a cock to control the supply of gas. For instance, if a building has a series of central lights throughout the length of a large room or hall, and a separate set of side lights, and others in adjacent rooms, then such an arrangement as is shown in fig. 962 would be suitable.

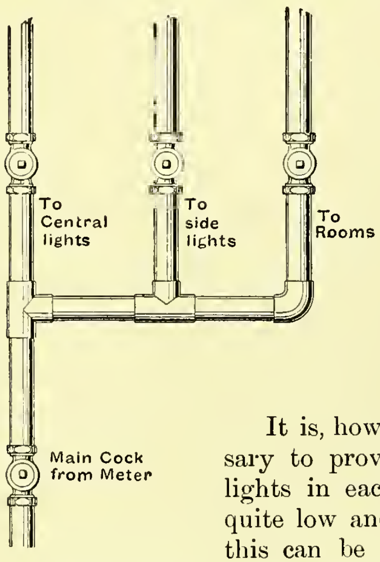


Fig. 962.—Arrangement of Separate Services

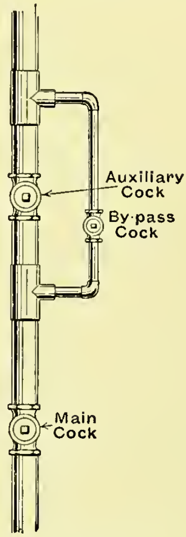


Fig. 963.—Arrangement of Bypass

It is, however, in many cases necessary to provide means by which the lights in each section may be turned quite low and yet not go out entirely; this can be done by the provision of **a bypass** on each pipe, as shown in fig. 963. When the main cock is left full on, and the bypass cock opened, the auxiliary cock can be closed and the small supply of gas necessary for the diminished lighting will then be obtained through the bypass.

In a large building, where the pipes are of great length, **a siphon** should be inserted in the main service pipe close to where it leaves the meter, and at the lowest point of the system, and all the pipes should be laid to drain to this point. In the case of a specially large building a box siphon should be provided. This is a cast-iron box of suitable dimensions, into the top of which a pipe is taken from the lowest point of the system. The pipe dips into the siphon to within about 1 in. from the bottom. An outlet fitted with a cock is also provided about $1\frac{1}{2}$ in. from the bottom for the purpose of drawing off any water that may accumulate in the system.

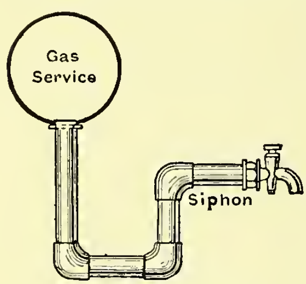


Fig. 964.—Pipe Siphon

Another simple and effective form of siphon for large dwellings is shown in fig. 964, and consists of a swan-neck outlet taken from the house supply pipe close to the meter. As this is at the lowest point in the service, any moisture that may condense in the pipes is collected and may be drawn off at the cock.

If it is impossible to arrange for a rise in the supply pipe from the main

in the street to the meter, it is essential that a siphon should be connected to this pipe before it enters the meter. The pipe should dip down nearly to the bottom of the siphon box, on which a small hand pump may be screwed if there is no room for a tap, and any accumulation of water can thus be removed.

Before taking the main service pipes throughout the building, it is necessary to determine the positions of the various lights in the different rooms, and also the kind of lights or burners that are to be used. Where **wall brackets** are to be fixed, service pipes of the proper diameter must be run from the main service pipe of the room to the foot of the walls on which the brackets are to be placed, and then up the walls to a distance of between 5 ft. 6 in. or 6 ft. above the floor. They must be finished off with an elbow to admit of the brass nose or nipple being screwed in to receive the bracket. Care must be taken that this nipple is long enough to project through the wood block against which the bracket is to be fixed.

For a centre light, if the main service runs across the middle of the floor above, a T piece must be inserted, to the outlet of which a short

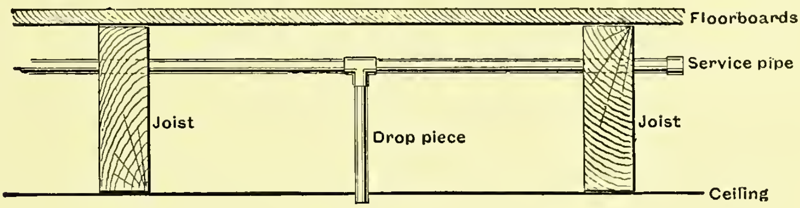


Fig. 965.—Support of Service Pipe for Drop Light

piece of pipe must be attached to pass through the ceiling below. If a separate branch is taken across the floor to supply a centre light, it is customary to fix an elbow on the end, and to attach the drop to this; but this is not a good plan, for the unsupported end is apt to vibrate. A better plan is to insert a tee at the point where the drop is required, and to continue the main until it rests on the next joist (fig. 965), or on blocking inserted between the joists for its support. Where it is necessary for the service pipe to run across the joists, notches should be cut out of the joists to permit the floor boards to be evenly laid in their place; but where the pipe is laid parallel to the joists, it must be firmly supported by staples or on blocks nailed between the joists.

If a pipe has to be laid when the floor boards are already nailed down, it should be run with the joists in order to obviate the necessity of taking up many boards. At intervals single boards should be cut, or taken up, and the required length of pipe screwed up and passed under the boards from one opening to another, until the whole pipe is in position, when it should be fixed to the joist with staples; on no account should the pipe be allowed to lie on the laths and plaster of the ceiling, as if any fittings are attached to it the ceiling below is sure to be damaged.

Testing.—When the whole service has been laid, and all brackets or other

gas appliances fixed, every tap or other outlet for gas should be turned off and the test dial (with which every meter should be fitted) observed. If this remains stationary, it may be concluded that every joint in the services laid down is perfectly tight; but if there is a movement, however slight it may be, all the work should be carefully examined until the leakage is detected.

Escapes of Gas.—It is essential that an escape or leak should be traced to its source with as little delay as possible. Coal gas can be readily perceived by its smell when in any quantity, but the location of a small escape is sometimes very difficult. A sensitive leakage indicator (fig. 966) is manufactured, the construction of which is based upon the law of the diffusion of gases; it is provided with an indicating hand on a dial, and will immediately reveal the presence of gas and give the approximate quantity that is mixed with the surrounding air. When in use, the back cover of the indicator is removed. This instrument does not locate the exact position of an escape, but as the defect is approached it is indicated by the larger quantity of gas registered. The most general method of detecting the whereabouts of a gas leak, however, is by smell, and the investigations are carried out somewhat in the following way. First, the spot where gas is perceived most strongly is located, then the main cock to the meter is shut off, and the premises are cleared as far as possible of all traces of gas. If the odour now disappears, owing to the open windows and doors, it may be concluded that the escape is on the premises themselves and not outside or in any other building; the pipes, therefore, from the meter outlet are carefully traced and every joint gone over, the main cock being in the meantime turned on again. Care should always be taken to see that no lights of any kind are allowed when the presence of a leak has been discovered. If the escape is thought to be large, it is usual to open up the ground outside, from the building to the main, to see that the service is sound, as gas often travels along the line of the service pipe, and finds an inlet to the building in this way. Gas has a great permeating power, and though the presence of gas is detected in one building, the escape may exist in another building, or even under the street.

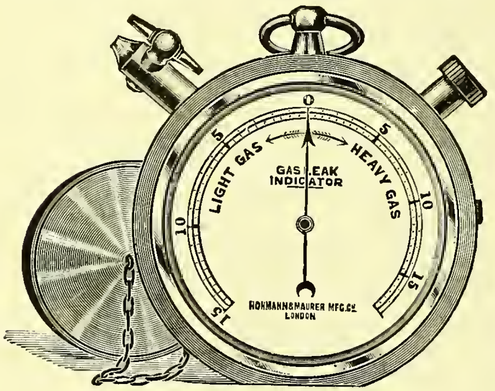


Fig. 966.—View of Leak Indicator

CHAPTER IV

METERS AND GOVERNORS

Meters are of two kinds, the wet and the dry. *The wet meter* is round, and contains a drum, which revolves in water by the pressure of the gas. The drum is divided into four compartments, each capable of containing a known quantity of gas. The gas enters from the main supply, and is discharged into the service pipes by the revolutions of the drum, and the drum is connected by worm gearing to the index box of the meter, which registers the consumption. *The dry meter* has two compartments, and each is fitted with a bellows capable of receiving and expelling a calculated quantity of gas, and actuated by its pressure. As the bellows extend, they expel a quantity of gas from the compartment in which they work, and become full themselves. A pair of valves in the valve box above them then admits gas to the compartment, and the bellows under the pressure recede and expel in their turn the gas they contained. The working of the bellows is connected by a suitable gearing to the registration index box. The amount of gas pressure absorbed by a dry meter is greater than that absorbed by a wet one, being about $\frac{5}{10}$ in., whereas in the latter case it would be about $\frac{3}{10}$ in.; but as of late years heavier pressures have been introduced, the difference is of little consequence.

The size of meter is, of course, entirely dependent upon the nature of the premises to be supplied with light, heat, or power, or, in other words, upon the quantity of gas required. Below is appended a table giving the sizes of meters and the quantity of gas which each will pass per hour, and also the diameters of the inlets and outlets. The particulars are the same for both wet and dry meters.

Nominal Size of Meter.	Measuring Capacity per Hour in Cubic Feet.	Diameter of Inlet and Outlet.
5 light.	30	$\frac{3}{4}$ in.
10 ,,	60	1 ,,
15 ,,	90	1 ,,
20 ,,	120	$1\frac{1}{4}$,,
30 ,,	180	$1\frac{3}{8}$,,
50 ,,	300	$1\frac{1}{2}$,,
60 ,,	360	$1\frac{3}{4}$,,
80 ,,	480	2 ,,
100 ,,	600	2 ,,

The rule for calculating the size of meter required for a building is to divide the measuring capacity of the meter per hour by the gas consumption per hour of the burners proposed to be used. It will be seen from the table that the nominal size of the meter is obtained by dividing the

measuring capacity by 6, this being the number of cubic feet consumed per hour by a large burner of the ordinary bat's-wing type. If burners consuming a smaller quantity of gas are used, a greater number of lights can be supplied from the meter; thus, if the burners consume 4 cu. ft. of gas per hour, a 10-light meter, which has a measuring capacity of 60 cu. ft. per hour, will be capable of supplying fifteen lights. In houses and in other buildings where all the lights are not burning at the same time, a 3-light meter is usually provided for any number of burners up to 6, a 5-light for any number between 6 and 10, a 10-light for any number between 10 and 20, and so on, the maximum in each case being double the nominal size of the meter.

House Gas Governors.—The pressure at the outlet of the meter varies during the twenty-four hours in almost every district, sometimes very considerably; and where gas is constantly being used throughout the day, and a constant pressure is required, a device, termed a *governor*, is

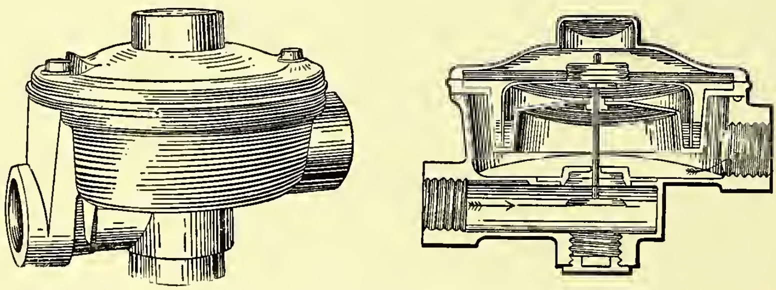


Fig. 967.—Gas Governor, Elevation and Section

usually fixed close to the outlet from the meter. The object of this governor is to prevent waste and also to provide a supply of gas for the fittings at a constant pressure, irrespective of the variations in pressure at the meter. A good type of governor consists of a small chamber fitted with a leather diaphragm, which rises as the pressure of the gas passing through the chamber increases, and draws up a small plug or valve, which partially closes the gas inlet to the chamber. Such a governor is regulated by placing small weights upon a platform, provided for the purpose, on the leather diaphragm, or by a regulating screw passing through the top portion of the casing.

Some governors, such as that shown in fig. 967, contain a cup filled with mercury, in which rests a bell of light metal weighted to the requirements of the position, and to which are attached the necessary spindle and plug for the regulation of the flow of gas.

CHAPTER V

BURNERS, LIGHTING DEVICES, AND GLOBES

The ordinary flat-flame or fish-tail burners are of two kinds: *the union jet* and *the bat's-wing.*

The union-jet burner (fig. 968) is a brass-cased burner fitted with an enamel top, which will not corrode or burn away in the same way as a metal top. Two small holes are drilled in the enamel cap at an angle of rather over 45° with the horizontal and inclined towards each other, their size depending upon the lighting capacity of the burner, and their effect being to discharge one jet against the other, forming a spreading or fan-shaped flame, and allowing the quantity of air necessary to produce the brightest jet to mix with the gas. Their efficiency is rather over $1\frac{1}{2}$ candle power for every foot of gas consumed.

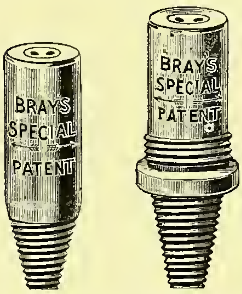


Fig. 968.—Union-jet Gas Burners

Fig. 969.—Bray's Bat's-wing Burner

With an even pressure they give an even flame, and before the invention of the incandescent mantle were much used for chandeliers and other positions requiring globes. The fish-tail burner derives its name from the shape of the flame it gives. If the best results are to be obtained, gas under a low pressure should be supplied, (say) $\frac{5}{10}$ in., and this, unless controlled by a governor of some description, must be regulated by the tap of the fitting to which the burner is attached.

The bat's-wing burner (fig. 969) has a brass case similar to that of the union-jet burner, but instead of two holes it has a slit across the top of the enamel cap. The cap is dome-shaped, and the slit is cut very evenly, but the flame is wider at the top than that of the union-jet burner, and has a great tendency to spread at the top corners and form two points.

A combination of the union-jet and the bat's-wing burners is called *the slit-union burner.* These produce a flame wider at the base than the bat's-wing, and of a more even character, and have been much used for street lighting.

Fig. 970.—Bray's Burner with Economizer

An economizer (fig. 970), which consists of a small brass expansion chamber, containing a muslin screen inside, and having a slit or two-holed burner on the top, is sometimes placed on the top of the ordinary Bray burner, and has the effect of largely increasing its illuminating power

This will be clearly seen from the appended table, quoted from a book by Mr. F. H. Hills, F.C.S.:—

Without Economizer.				With No. 7 Codac Economizer.			
Pressure Inches.	Size of Burner.	Consumption per Hour.	Ill. Power. Candles.	Pressure Inches.	Size of Burner.	Consumption per Hour.	Ill. Power. Candles.
1·75	No. 2	5·6	1·4	1·75	No. 2	5·6	16·6
1·00	„ 2	4·1	1·7	1·00	„ 2	4·1	9·6
1·75	„ 3	6·75	4·0	1·75	„ 3	6·75	18·0
1·00	„ 3	4·70	3·8	1·00	„ 3	4·70	11·4

From the above it will be observed that in the cases of both No. 2 and No. 3 burners the consumption remains the same, but with the pressure at 1·75 in. the illuminating power is increased in the former case from ·25 candle per foot of gas burnt to 2·96 candles, and in the latter from ·59 candle per foot of gas consumed to 2·66 candles. With the lower pressure there is a smaller increase in the illuminating power, but there is almost always more than 1 in. of pressure available.

Governor Burners.—In order to obtain the best results from any of the burners described above, it is essential that only as much gas as each really requires for the production of a steady clear flame should be allowed to pass through the burner. In buildings of many stories the pressure of gas on the top floors is considerably greater than that in the basement or on the ground floor, and, to ensure the best results, governors to regulate the pressure ought to be provided on the burners on the higher floors. The governor burners may be the ordinary Bray, with or without an economizer, but with a governor attached. The usual governor (fig. 971) is a small brass case fitted inside with a light metal cap, or float, which rests just over the orifice through which the gas enters. When the pressure becomes greater than is required, the float rises and reduces the size of the outlet until the required pressure is obtained. Governor burners, complete in themselves, such as that shown in fig. 971, are made by several makers, and can be bought for each particular inlet and outlet pressure.

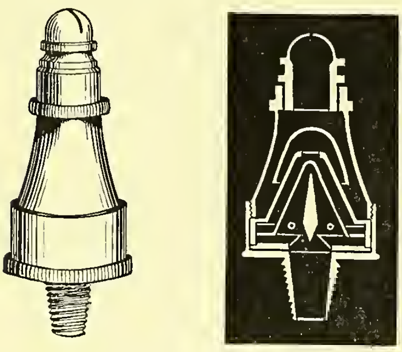


Fig. 971.—Governor Burner

The increase in pressure due to the height of a building is about $\frac{1}{16}$ in. for every 10 ft. If the burners themselves are not fitted with governors of the kind just described, **an initial governor** should be installed on the service pipe for every 30 ft. of elevation.

The albo-carbon light is obtained by means of a gas fitting in which the burners are so arranged that the heat which they give off plays either upon

the surface of a reservoir above them or upon a flat table in the same position, which conducts the heat of the flame to the reservoir. In the reservoir are placed pieces of re-crystallized naphthalene, which is a product of tar distillation, and which is a solid at ordinary atmospheric temperatures, but which melts at a temperature of between 170° and 180° F., and gives off a rich hydrocarbon vapour. The gas supply to the burners enters the reservoir and mixes with the naphthalene vapour, which largely increases its illuminating power, and the combined gases then travel to the burner. The light is very steady, owing to the expansion of the gas supply in the mixing reservoir. According to experiments, made by Mr. W. J. A. Butterfield, a light of 25 candle power is obtained with a consumption of $4\frac{3}{4}$ cu. ft. of gas per hour and ·02 lb. of albo-carbon. This form of burner is liable to smoke, but is certainly more economical than an ordinary flat-flame burner.

Regenerative Burners.—The principal feature of these is that the gas is burnt in an atmosphere of hot air. The necessary air is drawn into the burner after having circulated around the hot casing which conveys the spent gases from the outlet of the burner. The effect of the heated air supply is to raise the temperature of the flame and thus increase its illuminating power.

Fig. 972.—Sugg's No. 1 London Argand Burner

The Argand burner (fig. 972) consists of an annular steatite ring (forming the burner proper), on the top of which twenty-four holes of a prescribed diameter are drilled for the issue of the gas. Connected to this ring are three bent supply tubes, which are joined to the socket, by which the burner is screwed on to the wall bracket or other fitting. On the outside of the annular ring, or burner, is a gallery for carrying the straight glass chimney, and resting on the gallery is a metal cone the purpose of which is to direct a current of air up the outer surface of the gas flame. The main supply of air for proper combustion rises through the annular ring, and the flame itself is hollow, straight, and cylindrical. The best effect is obtained from this burner when the gas supplied is at a pressure of about $\frac{1}{2}$ in., but it depends also to a great extent upon its quality, as the holes in the top of the burner must be larger for a low-power gas and smaller for a richer or cannel gas. These burners are sensitive to variations in pressure, and should therefore always be used in conjunction with governors. Their illuminating efficiency may be placed at just over 3 candle power per foot of gas consumed.

Another form of Argand burner, and one which possesses the distinguishing characteristic of regenerative burners, has a subsidiary gallery around the burner and below that provided for carrying the ordinary chimney. The lower gallery is entirely closed in at the bottom, and is of sufficient diameter to support an outer chimney. By this arrangement the air supply to the burner must travel down between the outer

and inner chimneys, and, in so doing, becomes highly heated, so that it is supplied to the burner at a much greater temperature than the outside atmosphere. This, of course, increases the intensity of the gas flame; but owing to the fact that the light has to be transmitted through two chimneys, not much is gained.

Ventilating Burners.—In large buildings, where many burners are required, a system of ventilation, in which the burners act as the motive power for causing currents of air, is often found most useful. In many cases regenerative burners are utilized for the purpose. A casing or flue is made to carry off the products of combustion from the top of the burner, and is carried up to the ceiling (assuming that the fitting is suspended from the ceiling or roof), and is there connected to a flue that runs above this level to an existing chimney, or to the outside air, where a cowl is fixed on the outlet to prevent down draught. The casing is pierced or fretted along a portion of its length, and the foul air from the upper part of the room is drawn through the holes and carried away by the induced draught caused by the heat of the burner below. A better plan is to connect to the ceiling flue a canopy or inverted funnel, which overhangs the regenerative burner, and through which the gas-supply pipe to the burner may run.

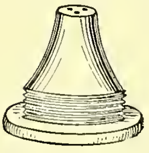


Fig. 973.—Nipple of Incandescent Burner

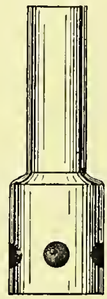


Fig. 974.—Mixing Tube of Incandescent Burner

Another burner used for ventilating is that known as "Sugg's Star". The same arrangements as regards the flue are, of course, necessary, but the burners are of the simple, flat, union-jet pattern, and do not require the same amount of attention as those of the regenerative type.

The incandescent burner consists of a Bunsen flame and a mantle manufactured from two rare earths, thorium and cerium.

The upright mantle is of hooded shape, and is composed of various substances, such as silk or cotton, but the kind in most demand is that prepared from a thread known as "ramie". This ramie is knitted into long stockings and cut to the required lengths, each being then gathered in at the top and an asbestos loop provided, whereby the hood may be suspended from the manganese burner fork. The mantle is then dipped mechanically into a solution composed of 98·76 per cent of thorium and 1·24 per cent of cerium. After the processes of draining and drying, the mantles are dipped into a solution of collodion, which has the effect of covering them with a fine film, thus rendering them fit for transport. The burners are of the Bunsen type, as before stated, provided with a small central hole for the reception of a manganese fork, on which the mantle is hung. The burners made by different firms vary in detail, but the working principle is always the same. In some a sleeve is placed around the bottom of the burner for the regulation of the air supply, and just above this is a nipple, shown in fig. 973, having a soft metal top, which is pierced by three or more holes, through which the gas enters the burner. The mixing tube (fig. 974) is screwed on to the nipple, and is

provided with inlet holes for the air supply necessary to form the Bunsen flame. Over the shank of this tube is placed the burner proper, which consists of a tube with an expanded head, covered with wire gauze, and having a metallic centre, forming the socket for the manganese fork. Fig. 975 shows the complete burner with mantle and chimney.

No. 1, fig. 976, shows Bray's improvement on the original form of burner. The movable sleeve allows more or less air to enter the mixing tube, and can be set, when adjusted to the requirements of any particular burner, by the small screw at the side. This burner is also fitted with a bypass, which enables the gas to be turned off, leaving only a small pilot light burning.

Fig. 976 shows two forms of bypass incandescent burners, No. 1 being an improved one of

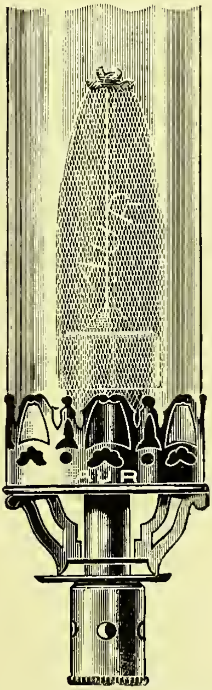
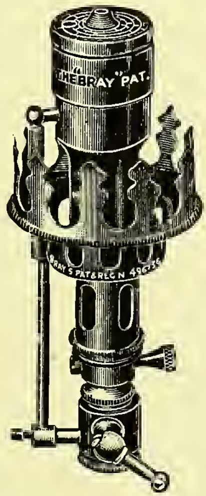
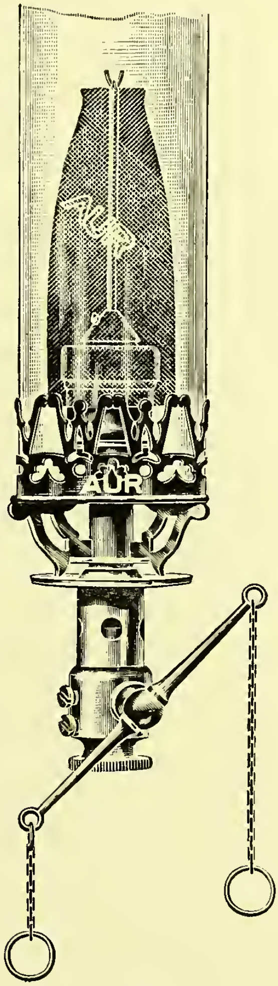


Fig. 975.—Incandescent Burner



No. 1



No. 2

Fig. 976.—Bypass Incandescent Burners

No. 1, Bray's; No. 2, Welsbach

Bray's, and No. 2 one of the original Welsbach pattern. The set screws near the bottom of the fittings are for regulating the supply of gas to the bypass.

The tops of these burners are made of a mineral called steatite, which is incombustible, and will not readily corrode.

When an ordinary incandescent burner of the C type is first lighted, it will give a lighting efficiency of over 15 candle power per

foot of gas consumed, provided that it is furnished with a suitable mantle. As the consumption of gas by a burner of this class is about 4 ft. per hour, a lighting efficiency of 60 candle power for one burner is obtained; when this is compared with the old flat flame of just under 2 candle power per foot of gas consumed, or a total efficiency of 12 candle power with 6 ft. per hour, the advantage of the incandescent burners will be apparent. Whereas five burners of the old flat-flame type are required to give approximately 60 candle power with a consumption of 30 cu. ft. of gas per hour, one incandescent burner and mantle, properly fitted and regulated, will give an equal light with a consumption of only 4 ft. This means that, if the price of gas is 2*s.* 6*d.* per 1000 cu. ft., the incandescent burner will cost ·12*d.* per hour as against ·9*d.* in the case of the flat-flame burner.

Larger incandescent burners are made for street lighting and public buildings which give good results, but

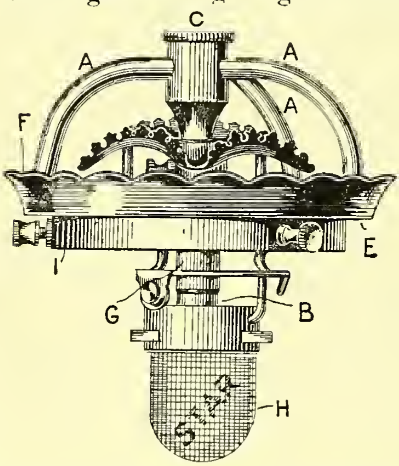


Fig. 977.—Star Inverted Burner without Globe

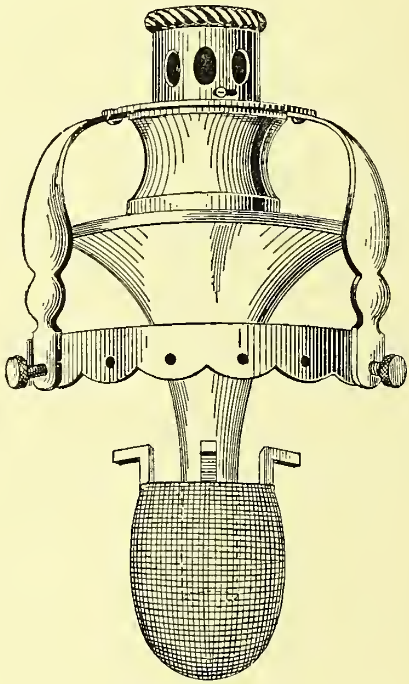


Fig. 978.—Bijou Burner

consume about 10 cu. ft. of gas per hour, giving a total illuminating power equal to from 200 to 240 candles. A special arrangement, however, must be provided for compressing the gas to be supplied to these burners.

Inverted incandescent burners, one of which, known as the "Star", is shown in fig. 977, are now often used in houses. The burner is fixed to the gas bracket by the internally screwed socket at C, through which the gas enters the burner. This socket is the same as that of the upright burner, but inverted. The air for the Bunsen flame enters at E, and passes through the supply pipes A, which are attached to the corona F, and are open below. The mixed gas and air travel down the tube G, where they are ignited, and around the end of this tube is suspended the mantle H, which is rendered incandescent by the gas flame issuing from the burner B.

The globe is arranged so that the top rim fits under the dropped portion of the corona marked I, into which three small screws are fitted to screw up into the curved lip of the globe and hold it in position. Great care must be exercised when adjusting the globe, as if the screws are too tightly set, the expansion of the glass, due to the heat of the flame, being greater than that of the metal surrounding it, will cause it to crack.

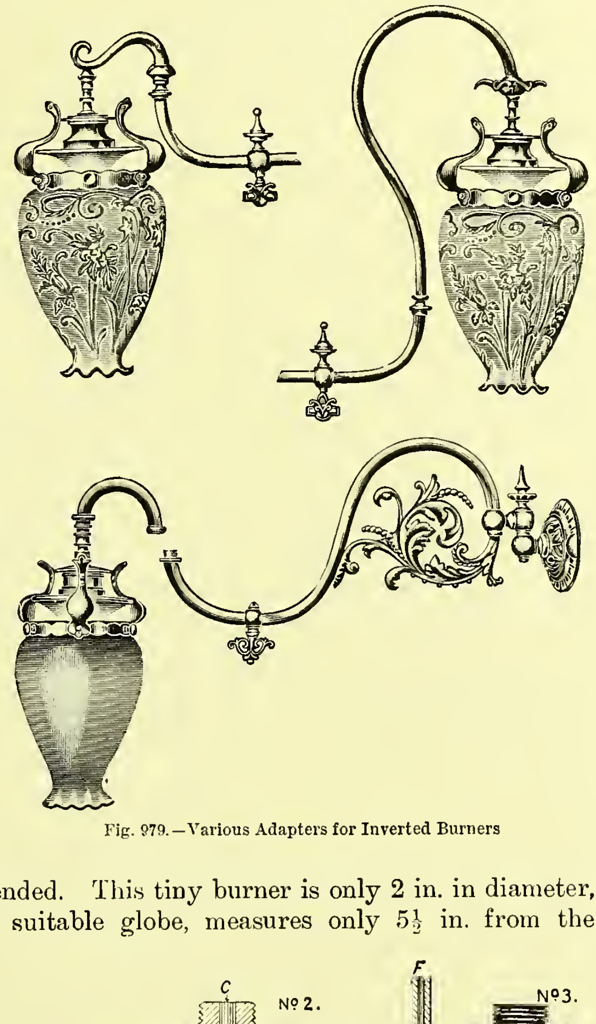


Fig. 979.—Various Adapters for Inverted Burners

The illuminating power of this class of burner is equal to about 22·31 candles per foot of gas consumed, and the consumption 2·37 cu. ft. per hour.

There are many makes of inverted burner, all good in their way, and the Star is only taken as an example to illustrate the system of working.

Where it is possible to make use of wall-brackets, the small inverted Bijou burner (fig. 978), made by the New Inverted Burner Company, is strongly recommended. This tiny burner is only 2 in. in diameter, and, when fitted with a suitable globe, measures only 5½ in. from the

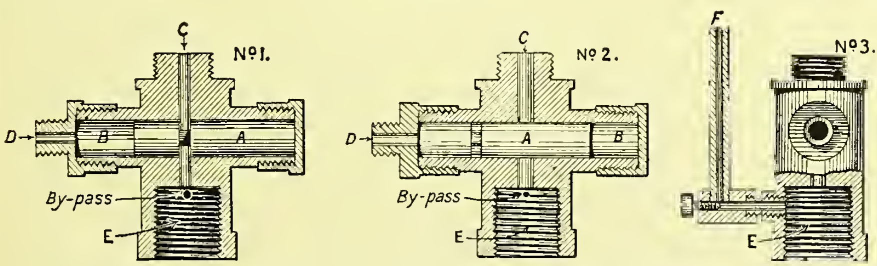


Fig. 980.—Pneumatic Valve.—No. 1, Open; No. 2, Closed; No. 3, Section of Bypass

tapped end to the bottom of the globe. The efficiency of this burner is equal to 13 candles per foot of gas consumed, and the consumption is only 1·25 cu. ft. per hour. Four of these burners are quite sufficient for a room

measuring (say) 15 ft. square, and the cost of the gas used (at 2*s.* 6*d.* per 1000 feet) is only ·18*d.* per hour for the four.

If brackets for upright incandescent burners have already been installed in a building, and it is not desired to go to the expense of purchasing new brackets for the new form of burner, the difficulty can be readily over-

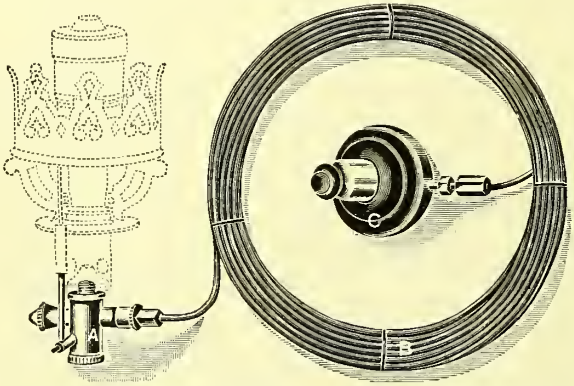


Fig 981.—Complete Pneumatic Bypass and Lighting Apparatus

come by the use of what is termed an adapter (fig. 979), which can be easily screwed to the existing bracket.

Pneumatic Gas-switches.—An excellent appliance is made for turning "off" or "on" incandescent or other burners, when these are out of reach. The apparatus consists of a small pneumatic plunger fixed to the wall of the roo in a convenient position, and from it is run a small brass tube,

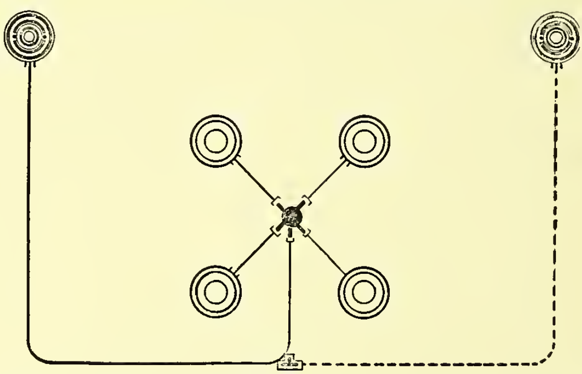
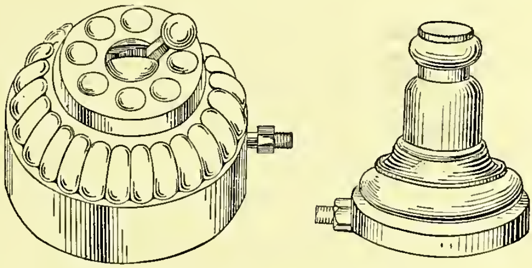


Fig. 982.—Arrangement of Four Lights worked by One or Two Pneumatic Pushes

which is connected to a valve box (fig. 980) attached to the burner. The brass tube is connected at D, and the pressure caused by pushing the plunger, or the vacuum formed by pulling it, moves the sliding valve A backwards or forwards, opening or closing the main supply of gas to the burner, which is fixed to the valve box at C. The gas pipe is connected at E, and a small bypass F (No. 3) from this point to the burner supplies the pilot light, which ignites the main supply of gas when the valve is opened.

Fig. 981 shows the whole apparatus, the burner being shown by dotted lines. A is the valve box, B the coil of brass tubing, and C the pneumatic push. An arrangement of four lights, regulated by means of one or two pushes, is shown in fig. 982, and two varieties of push are given in fig. 983.



No. 1 No. 2

Fig. 983.—Pneumatic Pushes

No. 1, Electric-switch pattern; No. 2, Ordinary pattern

Owing to the difficulty of bending the brass tubing, many small fittings are required, of which a few typical ones are shown in fig. 984.

An extension of this system has been invented, whereby the lights at several points or in separate rooms may each be lighted from one push. The push (fig. 985) has tubes leading from it to all the points controlled, and is provided

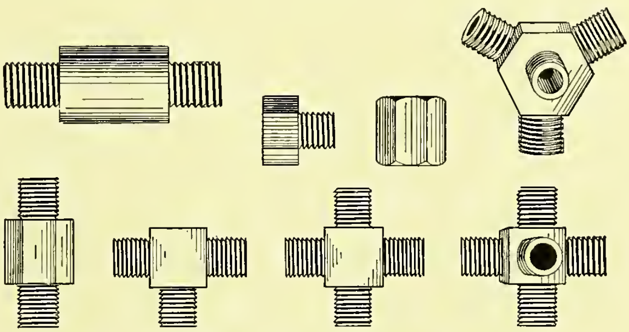


Fig. 984.—Fittings for Pneumatic Lighting Apparatus

with a numbered dial and a pointer; when the latter is placed over the number of the room or point to be lighted or shut off, and the push operated, the desired result is obtained at that place.

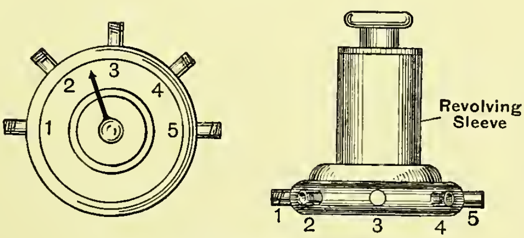


Fig. 985.—Multiple-point Pneumatic Push

Tests of Different Burners.—The following table shows the results obtained from three different kinds of C or upright mantles burning under the best conditions:—

MANTLE TESTS

Hours of Burning.	Candles per Foot.		
	Mantle No. 1.	Mantle No. 2.	Mantle No. 3.
50	17·7	18·0	17·0
75	17·0	17·0	12·0
100	16·7	17·0	13·3
200	15·1	17·0	14·0
300	12·5	16·0	9·5
400	11·5	15·0	8·0
500	10·5	14·9	8·0
600	9·0	14·5	*mantle*
700	7·2	14·3	*broke.*
800	7·0	12·0	
900	6·0	11·0	
1000	6·0	9·0	

It will be seen that all mantles do not give the same, or even regular, illumination when burnt for any length of time, and some increase in value after starting, and then suddenly drop very considerably. An ordinary C incandescent burner may, however, be expected under good conditions to give an illuminating power of 18 candles per foot of gas used to start with, and to consume 3·75 cu. ft. of gas per hour with a regular pressure of (say) 2 in.

The following table gives a comparison between flat-flame burners of good type and incandescent burners, and shows a saving in favour of the latter of 26 per cent as regards cost:—

	Hours in Use.	Total Consumption.	Consumption per Hour.	Cost of Gas at 2*s.* 3*d.* per 1000 Ft.	Maintenance Charge.	Total Cost.
		cu. ft.	cu. ft.	*s.* *d.*	*s.* *d.*	*s.* *d.*
Flat flame ...	18	6400	5·83	14 5	...	14 5
Incandescent C ...	18	3400	3·70	7 8	3 0	10 8

The table below shows the light given by three different kinds of inverted burners.

Burner.	Gas Consumed.	Illuminating Power.
Bray's	3·25 cu. ft. per hour.	20 candles per foot.
Star (with 3-hole nipple)	2·3 ,, ,,	22·31 ,,
Star (with 1-hole nipple)	2·37 ,, ,,	24·02 ,,

When selecting **globes** for gas brackets or pendants, care should be

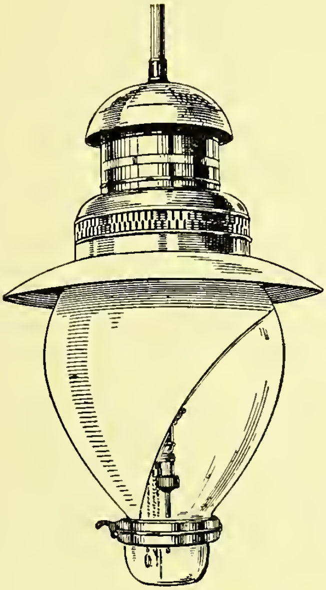


Fig. 986.—Southern Arc Outside Lamp

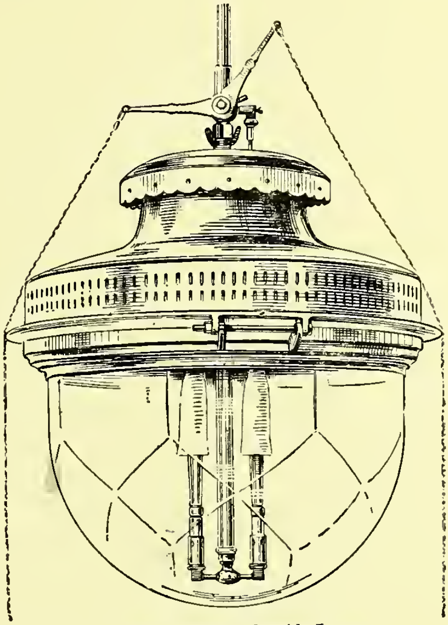


Fig. 987.—Rennie Outside Lamp

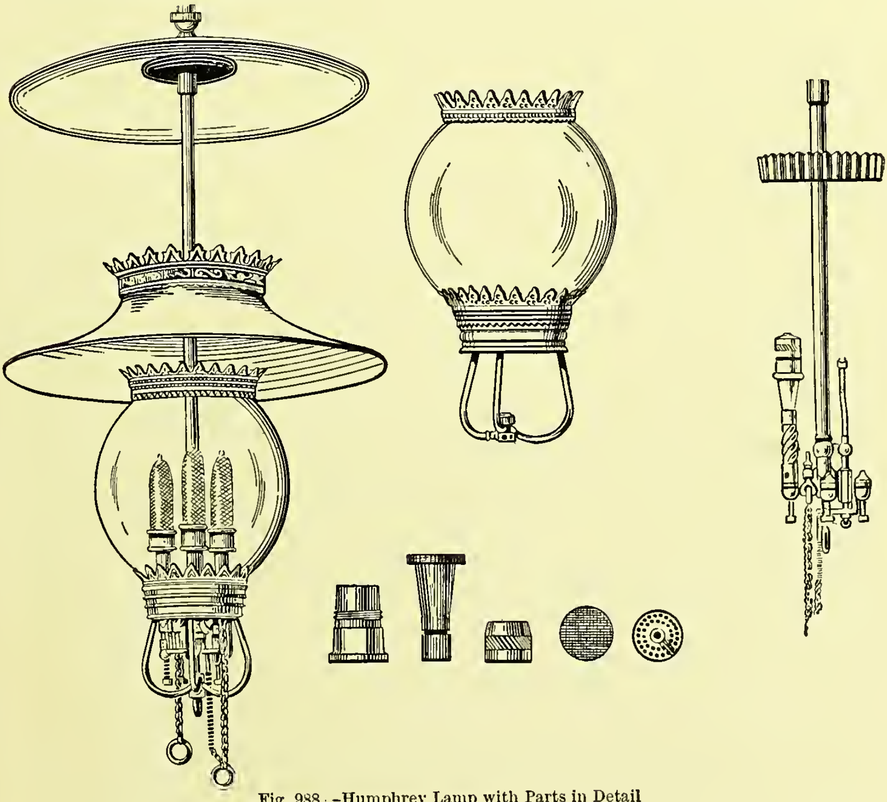


Fig. 988.—Humphrey Lamp with Parts in Detail

exercised as to choice of colour and material, as some globes prevent the transmission of light to a greater degree than others.

Clear glass intercepts 10·57 per cent of light.
Entirely ground glass intercepts 29·48 per cent of light.
Smooth opal intercepts 52·83 per cent of light.
Ground opal intercepts 55·85 per cent of light.
Ground opal with painted design intercepts 73·98 per cent of light.

The above figures are extracted from King's *Treatise on Coal Gas.*

Lamps for lighting shop windows externally are designed to display the names of the shopkeepers and the nature of their goods. The lamp illustrated in fig. 986 is a very efficient one of its kind, and has facilities for cleaning and attending to the burner, which of course is incandescent. The shopkeeper's name, or other information which it is desired to display, can be painted upon the opal reflector, which brilliantly lights up the shop window. The Rennie **M** lamp (fig. 987) is another form often met with.

For halls and entrances where high-power lights are required the Humphrey is a most suitable lamp. It consumes from 16 to 18 cu. ft. of gas per hour, and compares very favourably with the electric arc. The lamp itself is shown in fig. 988, and some of its component parts in detail.

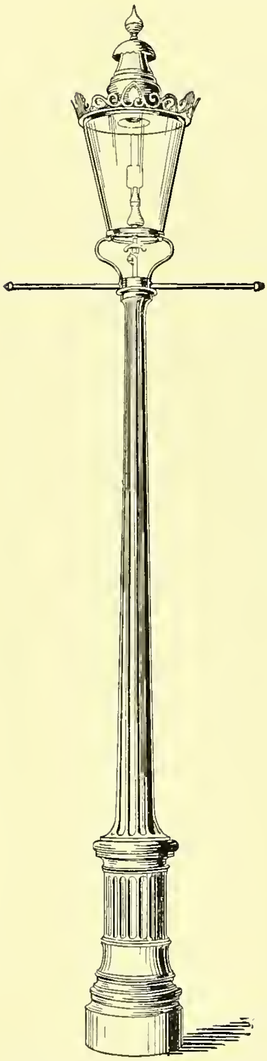


Fig. 989.—South London Gas Lamp

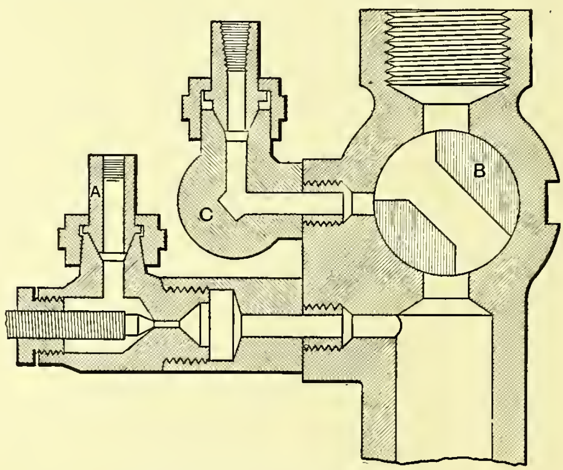


Fig 990.—Section of Street-lamp Bypass

Bypass for Street Lamps.—A most efficient form of **street lighting** is to be met with in South London, where in the main thoroughfares are fixed the Eddystone lamp columns surmounted by the South London lamp, fitted

with a Welsbach Kern incandescent burner No. 4, as shown in fig. 989. Each burner is governed to consume only a certain amount of gas, this quantity being such as shall give the best lighting power, and each is mounted upon a special bypass tap so arranged that the lamplighter has only to push the tap with his rod, when the gas is turned on to the burner, and a flash of light about 2 in. long shoots across the top of the chimney and disappears after igniting the gas to the mantle. The working of this bypass can be understood by reference to fig. 990. The main cock B and C is so arranged that when the tap is turned on, gas is admitted for a moment only to the bypass C before it is admitted to the burner; A is an auxiliary

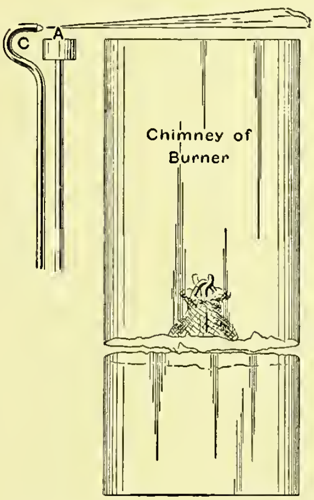


Fig. 991.—Flash Light of Bypass

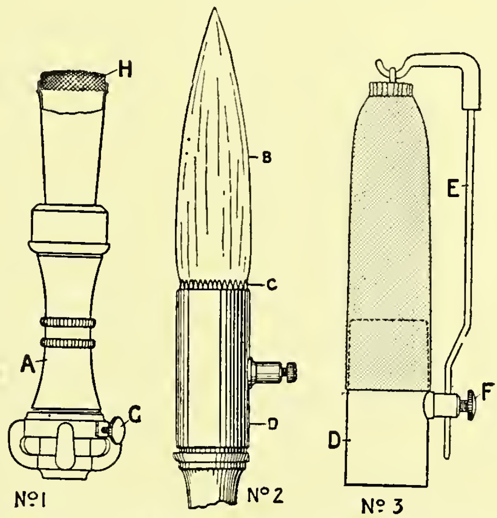


Fig. 992.—Burner for Keith-Blackman High-pressure Gas Lighting

bypass for a small pilot light, which is always burning. The tops of the two bypass pipes are arranged so that when gas is admitted to the pipe C it passes over the small pilot light A, and is ignited as shown in fig. 991.

The Keith-Blackman system of high-pressure gas lighting is a system whereby the illuminating power of the gas is increased to a very high degree by the gas being supplied to the burner at a high pressure, and being thoroughly incorporated with the necessary quantity of air in the mixing chamber of the burner tube. The system is only suitable for outside and street lighting, and for large public halls and factories.

The form of the burner is shown in fig. 992. The nipple A, through which the gas issues to the burner, is adjusted at the maker's works to suit the quality of the gas supplied in the district where it is to be fixed. When fixing the burner it is important to see that the jet of gas B, issuing from the gauze screen H, is perfectly straight and vertical, as a very slight divergence will spoil the shape of the flame and reduce the efficiency of the burner.

If the issue of the gas, and the mixture of gas and air, are properly adjusted, the resulting flame should be almost colourless with a slight tinge of violet, and at the base of the flame there should be a number of small

bright blue points C, distributed equally over the surface of the gauze about $\frac{1}{8}$ of an inch in length. If too little air is admitted to the burner the points will attain a green tinge, and if too much air is admitted they will become considerably longer. The mantle is supported by the rod E, which is fixed to the brass case D by the set-screw F. A new mantle, after being placed in position, should be burned off by igniting it at the bottom,

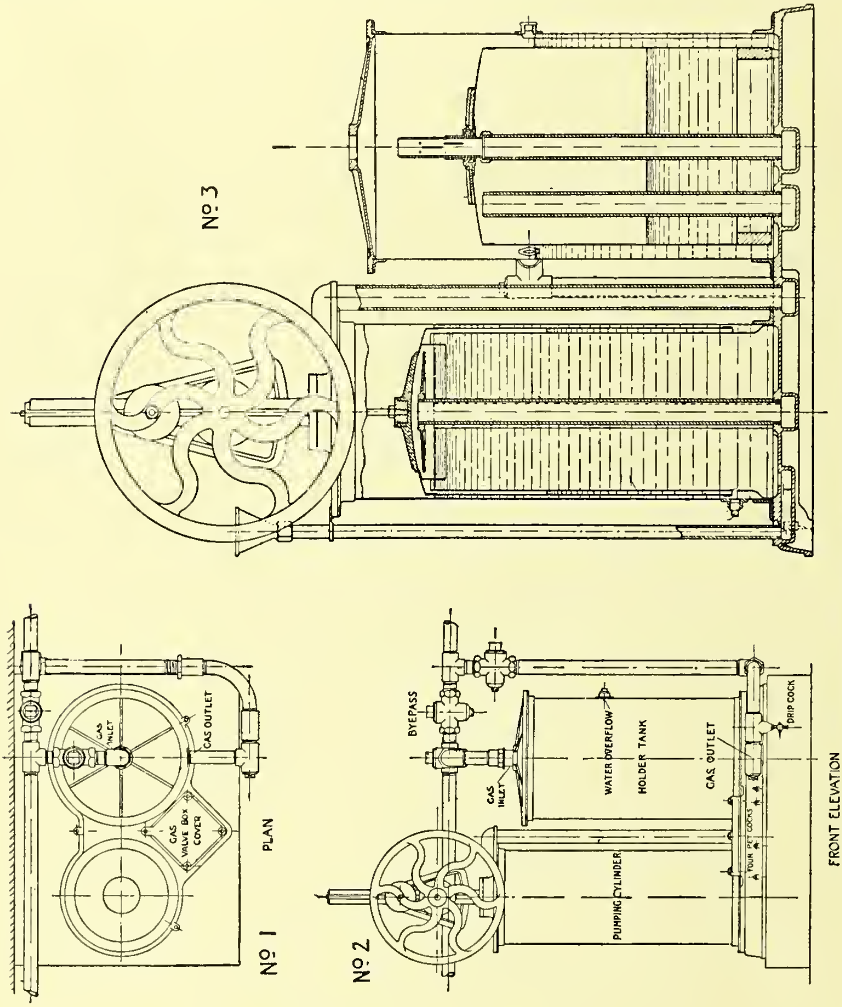


Fig. 993.—Compression Apparatus for Keith-Blackman High-pressure Gas Lighting

and should then be worked on the low-pressure gas for a time before the high-pressure gas is given to it. To obtain the best lighting effect a milled screw or air-regulator G is provided whereby more or less air can be given to the burner; when the point of greatest efficiency has been found this screw should be tightened, and no further attention to the burner should be necessary.

One set of the necessary compressing apparatus (fig. 993) creates a continuous pressure equal to a 10-inch column of water, and the burner has

a consumption of just over 10 cubic feet of gas per hour, or (say) 1 cubic foot per hour for each inch of pressure. The consumption of gas varies, however, as the pressure increases; for example, with a pressure of 12 inches the consumption of the burner becomes 15 cubic feet per hour. The lighting effect of the burner is 28 candles per cubic foot consumed per hour, and if 10 cubic feet are consumed the total lighting effect of each burner is (say) 280 candles.

The cost of producing this high-pressure gas differs according to the motive power employed to work the compressing apparatus. If water is used to drive a water motor, the heavy charges for water make the cost of running the apparatus about 5*d.* per 1000 cubic feet of gas compressed, but by the use of a small gas engine of a nominal 1 horse-power value this cost is reduced to ·55*d.* per 1000 cubic feet of gas compressed. The compressing capacity of the No. 3 apparatus, shown in the illustration, is 500 cubic feet of gas per hour, giving a continuous pressure of 10 inches, provided that the 500 cubic feet per hour are not exceeded.

No special foundations are necessary for the installation of the apparatus, but it is found advantageous to raise it a few inches above the floor level on some sound runners of timber.

Either a wet or dry meter may be employed having a capacity of 200 to 250 lights, and this should be fixed only a few feet away from the compressor. The internal diameter of the gas supply pipes both to and from the meter should not be less than 1½ in.

CHAPTER VI

GAS FIRES AND STOVES

Burners for gas fires and stoves may be divided into two classes—(1) Those in which no air is mixed with the gas before ignition, and which consequently have luminous flames; and (2) those having an air supply for combustion, and for which a mixing chamber is provided.

The heating powers of the two kinds of flame, viz. the luminous flame and the Bunsen flame, are precisely the same per cubic foot of gas consumed if proper conditions are observed in the burning in both cases.

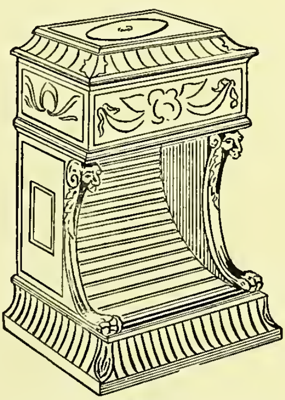


Fig. 994.—Radiating Luminous Gas Fire

Of the **luminous-flame stoves** there are two kinds in general use. The first kind has an iron or glazed earthenware casing (fig. 994) containing a curved sheet of copper, in front of which a row of gas burners is usually placed. The heat is obtained by refraction from the copper, and radiation and conduction from the casing. These stoves are, as a rule, used only in places where it is impossible to arrange

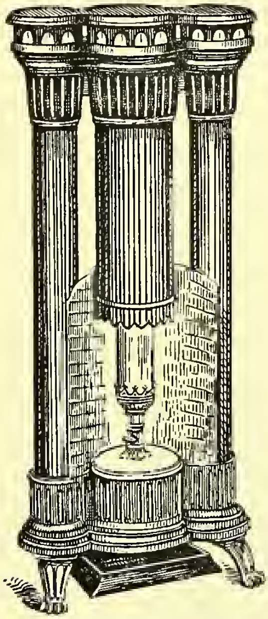


Fig. 995.—Tubular Condensing Gas Heater (Luminous)

for a flue. They vitiate the atmosphere in the same way as ordinary gas lights, and do not supply very much warmth.

Condensing stoves, of which one variety is shown in fig. 995, condense about 1 pt. of water for every 30 cu. ft. of gas consumed, the hydrogen in the gas uniting with the oxygen of the air to form water. The burners in most of the stoves are of the Argand type, and the products of combustion are carried up and down through a series of tubes until their temperature becomes sufficiently reduced for the water vapour to condense. The water, which trickles down the tubes and is collected in a pan at the foot of the stove, is not pure, but contains sulphur compounds and other impurities. When coal gas is burnt, carbonic acid gas is always formed, and in these stoves this is not condensed or absorbed by the water. The stoves, therefore, should never be used in dwelling rooms, unless connected to a flue. They are necessarily large, because so much surface has to be provided for the condensation of the products of combustion.

Condensing stoves are also fitted with a grate containing asbestos fire balls (fig. 996), the flame being the non-luminous or Bunsen kind. The gas consumption is greater in these than in the stoves previously mentioned, because this class is intended for warming halls and

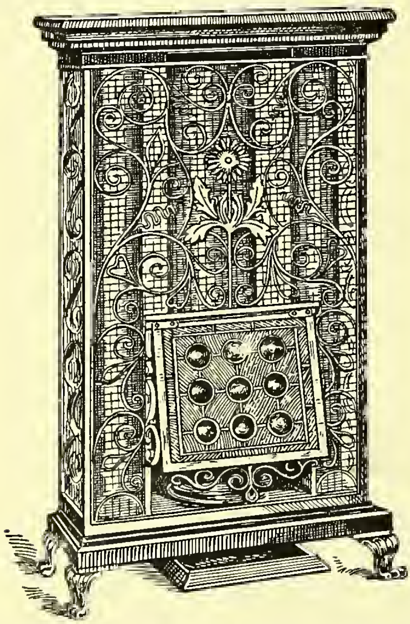


Fig. 996.—Tubular Condensing Gas Heater (Non-luminous)

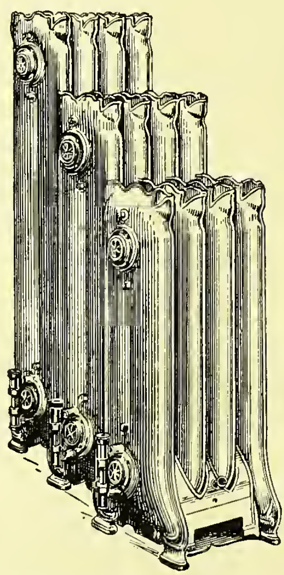


Fig 997.—Gas Steam Radiators

rooms of fairly large dimensions. In other respects, what has been said above with reference to the luminous condensing stoves is equally applicable to these.

Another form of condensing stove, known as the radiator pattern, has the same failings as those previously described. Fig. 997 shows a group of three sizes.

No gas stove should be placed in a dwelling room without being connected to a flue to carry away the products of combustion. Many so-called condensing stoves are recommended as being capable of burning gas without vitiating the atmosphere, but such a statement is not correct.

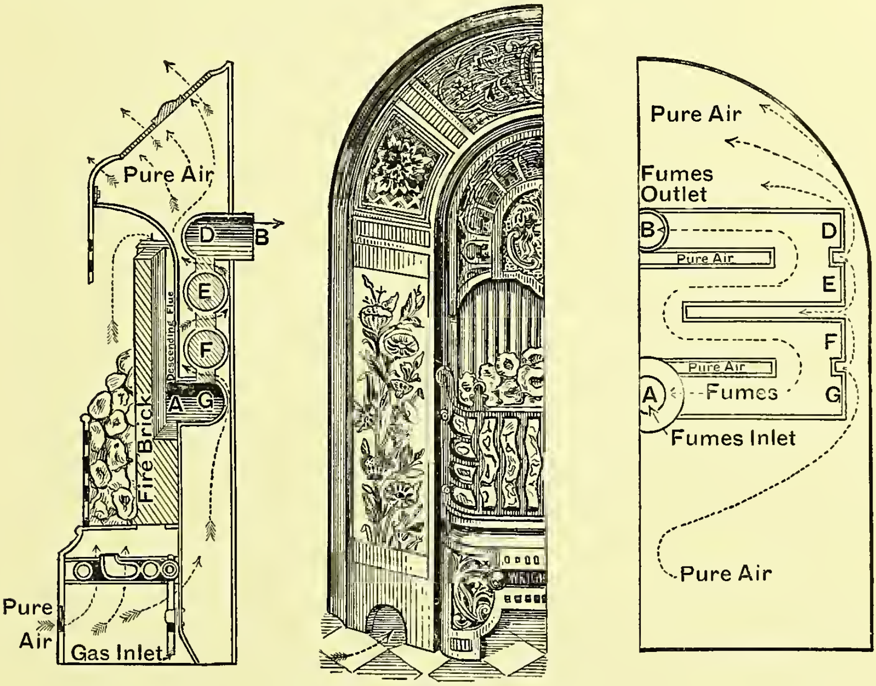


Fig. 998.—Gas Fire with Heating Tubes

The fuel-ball fire is the best, both from a heating point of view and from that of economy. Such fires are made as nearly as possible to match the ordinary coal fire and grate.

The gas burner, which is of the Bunsen type, is placed at the bottom of the grate, and the grate itself is filled with irregular balls made of incombustible material, such as fireclay or fireclay and suitable silicates, and some have threads of asbestos fibre intermingled to give iridescent points to the hot fuel. The gas is burnt in the grate of the fire, and the hot waste products, after partially spending themselves in heating the balls to incandescence, travel through tubes so arranged that much of the heat left is utilized in warming the casing. The fumes are conveyed to a flue entering the chimney, as shown in fig. 998.

The course of the waste heat from the burner will readily be traced by

means of the letters in the two sections. The waste heat warms the air chambers and ducts, and consequently causes a current of pure hot air tc enter the room from the top of the iron casing. The burner itself, shown in plan and section in fig. 999, is arranged to ensure the proper mixing of the gas and air before ignition takes place.

When one of these fires is fitted in a room with a fireplace, much greater heat will be obtained if it is placed in front of the existing grate and a

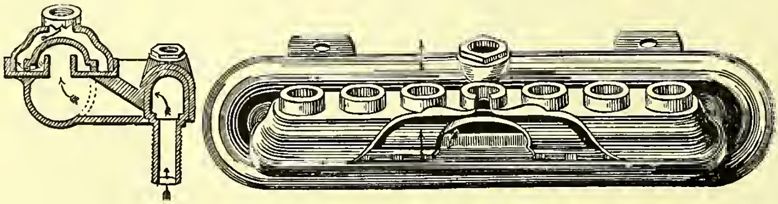


Fig. 999.—Burner for Gas Fire

piece of sheet iron fixed across the old opening, than if this were left open, for much of the heat derived from the hot-air chambers will in the latter case be drawn up the chimney by the draught caused by the escape of the products of combustion. A hole will be required in the sheet iron for the exit flue of the gas fire to pass through, and on the end of this flue should be fixed an elbow extending about a foot up the chimney.

With the supply full on, a fire of this kind consumes from 50 to 60 cu. ft. of gas per hour, but when once the fuel balls have been raised tc red heat, the supply may be turned off until no blue flame is visible above them. If this is done, the gas consumption may easily be reduced by one-half.

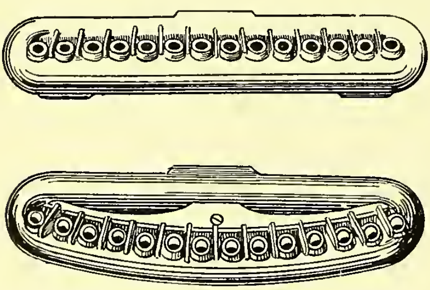


Fig. 1000.—Two Burners for Ordinary Fire Grates

When starting a gas fire, the gas should not at once be turned full on, as, owing to the low temperature of the materials, there is often a lack of draught which results in the products of combustion entering the room and causing an unpleasant smell. To avoid this the supply should be turned partly on until the clinkers begin to get hot, when a draught will be caused, and the supply may then be turned full on, and may be reduced again when the required degree of incandescence has been obtained.

Such a gas fire as that just described will heat a room (say) 16 ft. square efficiently, and taking the cost of gas at 2*s.* 3*d.* per 1000 cu. ft. (at which figure it is now supplied in South London), and allowing for the supply being full on for (say) the first hour, the cost will be just over 1·7*d.* for the first hour, and this is easily reduced to ·85*d.* per hour for the following hours during which the fire is burning.

Another form of ball fire (fig. 1000) consists of a specially made burner which will fit all ordinary fire grates, and is placed immediately under one

of these with the burner apertures just protruding through the grate bottom. The grate is filled with the refractory balls. The exit flue or register of the fireplace should be adjusted so that the products of combustion are all carried away without undue waste of heat. The writer has had experience of such a fire in a room measuring 15 ft. by 17 ft., and 13 ft. high, which is efficiently warmed with a gas consumption of only 27 cu. ft. per hour. This represents a heating cost of ·75*d.* per hour with gas at 2*s.* 3*d.* per 1000 cu. ft.

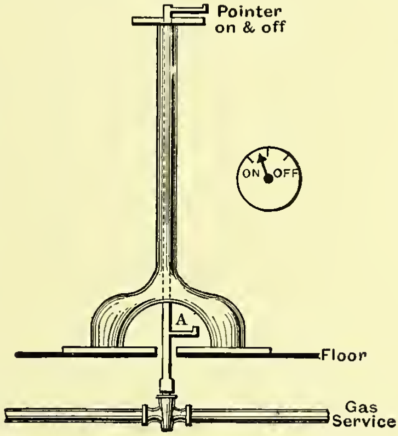


Fig. 1001.—Standard Gas Cock

The taps provided for turning the gas off and on should be sunk in the floor, to prevent the risk of their being turned by an accidental knock or kick. Small hinged disc plates are cast with the word GAS in relief. They are let in flush with the floor boards, and give sufficient room for the fingers and thumb to be inserted to turn the tap

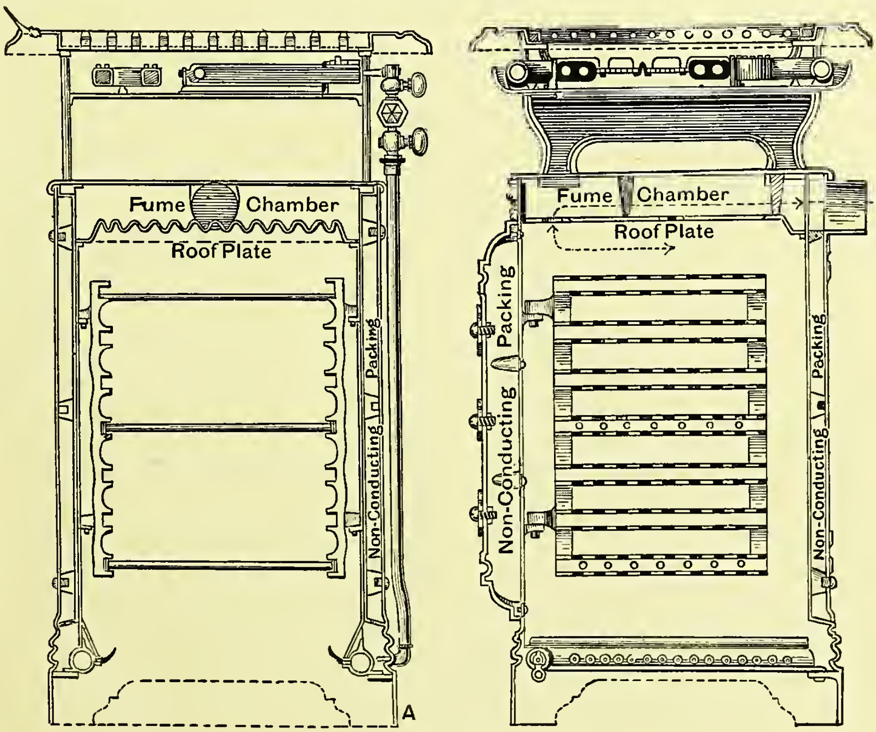


Fig. 1002.—Sections of Gas Cooking Stove

or, should the tap be too low down for this, a box spanner is provided which fits the top of the cock below. A more convenient arrangement is

the extended gas-fire tap (fig. 1001). This consists of a stand pipe, usually of brass, through which runs a solid rod on the end of which is the box spanner. On the top of the stand pipe and attached to the spanner rod is a handle which works over a dial indicating "on" and "off". The whole apparatus is firmly screwed to the floor boards. It has an opening at A (fig. 1001), with a duplicate handle attached to the spanner rod, so that the cock can be turned by anyone who is stooping to light the fire.

Gas Cooking Stoves.—One of these is illustrated in fig. 1002. The hot plate has three ring burners and a griller with every convenience for removing the burners for cleaning purposes, and the oven portion is fitted with two burners running along the sides at the bottom, and with detachable side pieces, which can be taken out for the same reason as the burners. The sides of most gas cooking stoves are double, the space between the two thicknesses of metal being packed with slag wool to prevent waste of heat by radiation. The stoves are made of cast iron, the sides, back, top plate, &c., being held together by screws and nuts. The oven is fitted with an outlet at the top, and the fumes from it are conducted through a fume chamber to preserve as much heat as possible. All the parts, as far as possible, are made so that they can be readily removed for cleaning, or replaced should they be broken or worn out with use.

CHAPTER VII

ACETYLENE GAS

Composition.—According to Berthelot, this gas is composed, when in the pure state, of 92·3 per cent of carbon and 7·7 per cent of hydrogen, the carbon being to the hydrogen as 12 to 1. The chemical formula is C_2H_2. Professor Lewes, who is one of the greatest authorities on this subject, finds that at 15° C. (59° F.), and under a pressure of 760 mm. (29·6 in.), 10 volumes of water will dissolve 11 volumes of acetylene. The gas is generated by the chemical action of water on calcium carbide, a pound of pure calcium carbide yielding about 5·82 cu. ft. of acetylene gas.

Calcium carbide is manufactured with the aid of electric furnaces which bring about the direct combination of calcium and carbon. Its chemical formula is CaC_2, and it consists, when pure, of 62·5 per cent by weight of calcium, combined with 37·5 per cent of carbon. It is described by Lewes as a "beautiful crystalline semi-metallic-looking solid", and is neither explosive nor inflammable, but when exposed to the atmosphere it quickly changes into powder, this change being due to the moisture present in the atmosphere. As stated above, the electric furnace is employed to obtain the heat necessary for the combination of the calcium and the carbon. Freshly burnt lime (calcium oxide) and carbon of the purest forms obtainable must be used, for reasons which will be dealt with later. The carbon may be foundry coke, anthracite coal, or charcoal. Gas coke is not suitable

on account of the sulphur which it contains. The lime and carbon are mixed approximately in the proportion of 100 parts by weight of lime to 70 parts of carbon, and ground to a fine powder before being placed in the furnace.

In packing carbide every care must be taken to exclude the air, and to do this the drums or canisters are heated, and the material packed in them, and air-tight lids put on while they are still warm. In this way no air of a moist nature is surrounding the carbide. Carbide is seldom packed in quantities of more than 1 cwt., and the drums are specially strong, as the material is heavy. When several drums or smaller canisters are stored, great care should be exercised to see that efficient ventilation is provided, so as to prevent the risk of any explosion by slight or undetected escapes of the gas from defective packages.

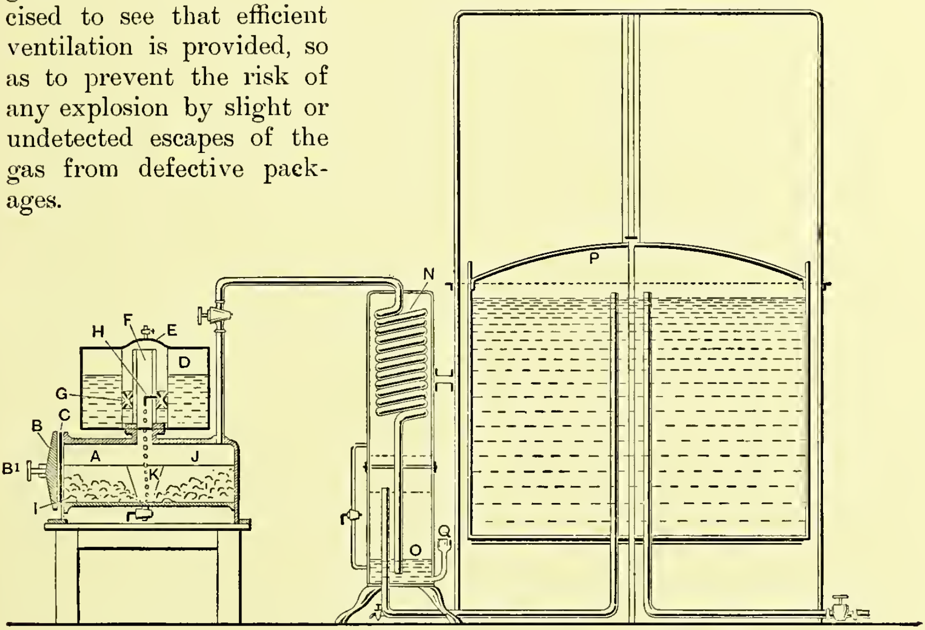


Fig. 1003.—Forbes's Acetylene Generator

Generators.—To generate acetylene gas all that is required is an apparatus which will bring water into contact with calcium carbide in some suitable manner. This is accomplished by generators, which may be of two kinds:—

(1) Those in which water is brought into contact with the carbide, the carbide being in excess during the first part of the operation; and (2) those in which the carbide is dropped into the water, the water being in excess.

The first class may be sub-divided into (*a*) generators in which the water rises to the carbide, (*b*) those in which it drips on to the carbide, and (*c*) those in which a vessel full of carbide is lowered into the water and withdrawn as the pressure of gas becomes excessive. Some generators are designed with the idea of making the gas as it is consumed, so as to do away with the necessity of a holder and so save space, and others with devices for regulating and stopping the generating process at will. These

are termed automatic. Other generators fill or supply a storage holder, and are termed non-automatic.

The first automatic generator was of the drip type, and was made by Gearing in 1895. It consisted of an apparatus in which water was allowed to drip upon carbide contained in a water-sealed generator. The gas was led through a condenser into a holder, the rising bell of which cut off the water supply when the bell was about two-thirds full of gas. As the gas was used from the holder the bell descended and turned the water on again.

A newer form of generator, designed and patented by Sir Charles Forbes, is shown in fig. 1003. The generator A consists of a cylinder closed at one end and having a cover B on the other, which is clamped against an indiarubber washer C, by means of the screw B[1]. On the top of this is a water vessel D, containing an inverted gas bell E, supported on and fixed to a wide pipe F, which passes up inside the inverted gas bell, nearly to the top. The bell is supported in position in the tank by means of a cone G formed on the upright pipe, which also acts as a valve for cutting off the water when recharging, or for stopping the action of the generator. The automatic action of the generator does not, however, depend upon this valve. When the carbide-container is charged, and the tank above filled to the required level with water, which may be done by hand or by a supply tank, the water rises below the lower edge of the inverted gas bell until it reaches a small tube H, which is screwed through the side of the upright pipe and is bent over inside it; from this pipe the water drips into the centre of the carbide-container beneath it.

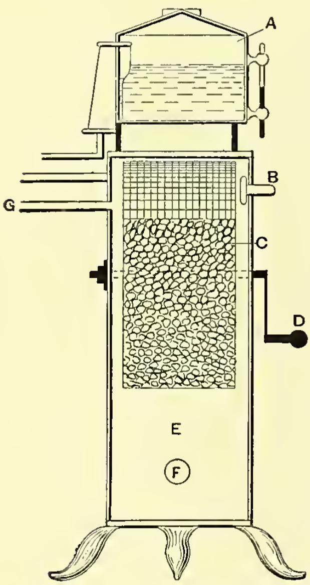


Fig. 1004.—Generator with Revolving Cylinder

The carbide-container is provided with a V-shaped channel K in the centre, so that no carbide can be placed immediately under the drip. When the water enters the channel it spreads both ways and slowly attacks the carbide, and the gas generated passes in at the top of the cooling coil N (which is surrounded by water), and is discharged through a small quantity of water in the washer O, from which it is conveyed to the holder, P. As the holder rises, its gradually increasing weight counterbalances the head of water in the water vessel D, and the water under the bell is automatically displaced by gas until the level is below that of the small dripping tube. The flow of water then ceases, and no more gas is generated until the holder falls below the counterbalancing point.

Sometimes in this class of generator trouble is caused by the lime of the carbide forming a wet mass and preventing the water which drips upon it from attacking the unspent carbide. To guard against this the generator and its water supply are sometimes separated from the carbide-holder, as in fig. 1004. The water tank A is above the generator,

and the water drips through a fine gauze screen B in many small streams on to the carbide contained in the revolving cylinder C, and the gas passes through the pipe G to the holder. By turning the handle D the spent carbide can be emptied out of the cylinder into the lower part E of the generator, from which it can be removed through the gas-tight door F.

Another type of generator is shown in Fig. 1005. Water is admitted to the generator A, containing the carbide, by the cock H, and the gas formed passes through the coil of pipe in the water cistern C, so that any moisture

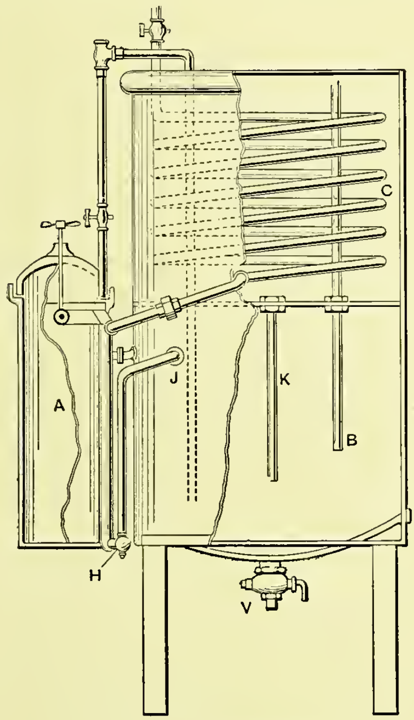


Fig. 1005.—Automatic Generator

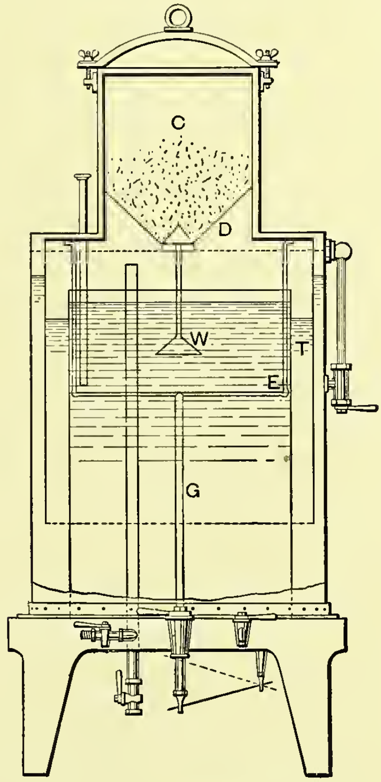


Fig. 1006.—The Acetylite Generator

in the gas is condensed and runs back into the generator through the pipe J, while the gas passes on to the service pipes. Should there be any excess of pressure in the generator it drives the water back into the lower holder B, and the excess of gas, also passing through the same tube and collecting in B, drives the water from B through the pipe K into the coil cistern C. Consequently the tank B acts as a displacement holder, the pressure in which increases with the depth of the water driven up into the cistern C. As soon as the consumption exceeds the generation, the acetylene stored in the displacement holder passes through the generator into the coil, and is followed by the water for the formation of more gas.

The Acetylite Generator (fig. 1006) is of that class which allows the carbide to drop into the water. It consists of an inner and an outer tank placed on a base plate, with a gas bell fitting between the two.

This has a neck of smaller diameter C (closed at the top by a gas-tight cover with screw clamp) in which is hung a conical carbide hopper fitted at the bottom with a conical valve D, which rests on a suitable seating and has attached to its under side a rod and weight W. From the crown of the gas bell is hung a perforated grid E, fitting in the inner tank, into which it projects when the bell is in place; the gas exit pipe and raising rod pass through holes in the grid. On the base plate water, gas, and sludge cocks are fitted. Granulated carbide is placed in the hopper of the gas bell, and as the latter sinks, the weight on the end of the valve rod strikes the raising rod G, lifting the valve and allowing some of the carbide to drop into the water. The gas then generated raises the holder and stops the fall of carbide by causing the valve to shut until the gas is used and the bell descends again.

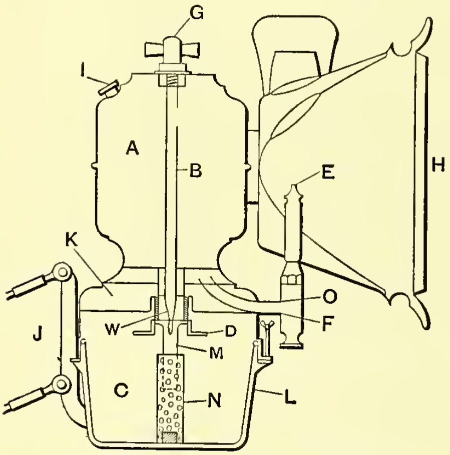


Fig. 1007.—Acetylene Bicycle Lamp (Section)

The chief points to be taken into consideration when selecting or designing a generator are:—1. That the temperature of the gas should be low; 2. That the carbide should attain complete decomposition; 3. That there should be low pressure in every part of the apparatus; and 4. That there should be facilities for the complete removal of air from the apparatus before the generation of gas takes place.

As considerable heat is evolved when carbide of calcium is acted upon by water, arrangements for cooling the gas before it enters the holder are necessary. The quantity of water required per pound of carbide used varies according to the type of generator. In the drip type about 1 pt. of water to every pound of carbide is required.

Acetylene is adaptable for use in **cycling lamps**, and fig. 1007 shows a lamp known as the "Phenomenon". The chamber A is filled with water through the milled screw I. The water is prevented from leaving this chamber by the screwdown valve B, which is actuated by the fly-nut G, and screwed down on to its seating at K. The bottom portion of the lamp L is capable of being removed, and with it the inner cup C. This inner cup has, fixed to the bottom of it in its centre, an upright perforated tube N, which the tube M enters. The carbide is placed around the tube N, and the water supply, regulated by the valve B and the nut G, fills the perforated tube and percolates through it to the carbide. The gas formed is filtered through a pad of soft wool D, and passes into the pipe O which leads to the burner E. The combustion chamber is arranged as a reflector, through which the burner passes near the bottom, and at the top of the lamp is a protected opening for the escape of the heated gases. The front H is glazed, and has air inlets around it. The lamp is fixed to the cycle in the usual way by the spring supports J.

Removal of Impurities.—As previously stated, it is absolutely essential that acetylene gas should be of the greatest purity possible, and to ensure this the best carbide should be used. The impurities to be met with in commercial carbide consist principally of calcium phosphide, calcium cyanide, aluminium sulphide, and magnesium nitride, which, when decomposed by water, will form phosphoretted hydrogen, sulphuretted hydrogen, and ammonia, mixed with the pure acetylene. Phosphoretted hydrogen, when burning in the acetylene flame, forms phosphorus pentoxide, which escapes into the atmosphere. This mixes with the water vapour always present in the air of rooms, and becomes phosphoric acid, which is injurious to health. The best method to adopt for the removal of these impurities is that advocated by Mr. W. J. A. Butterfield, and is as follows. In the first place the acetylene gas, as generated and cooled by the cooling coil, is passed through a washer containing water, which rids it of most of the ammonia and part of the sulphuretted hydrogen present. It is next passed through a vessel charged with lime to remove all traces of the ammonia, and afterwards through another vessel containing chloride of lime. This latter extracts the phosphoretted hydrogen and also the remainder of the sulphuretted hydrogen. If the acetylene were not passed through the vessel charged with lime, the ammonia would combine with the chloride of lime, forming chloride of nitrogen, which is one of the most explosive compounds known.

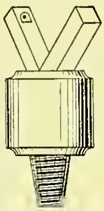


Fig. 1008.—Billwiller's Acetylene Burner

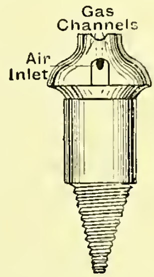


Fig. 1009.—Acetylene Burner

Burners.—The rules to be observed in order to ensure the proper combustion of coal gas apply in the case of acetylene also. The pressure must be regulated and the necessary air supply arranged. Practically the largest acetylene burner that can be used for domestic purposes is one consuming 1 cu. ft. of gas per hour. This gives a lighting value of about 32 candles per foot.

The difficulty at first met with in the use of acetylene was the formation of carbon on most of the burners used, with the result that smoke was given off. Now, however, many burners have been invented which prevent this trouble. Billwiller's may be taken as a good example (fig. 1008). Two jets are provided, so that each flame impinges upon the other. The jets are placed far apart in order to obtain the air necessary for proper combustion and to keep the gas cool. Immediately above the gas orifice in the steatite burner a small platinum plate, having an orifice rather larger than that in the steatite, is fixed at a distance of about ·5 mm. The gas, issuing from the hole in the steatite, rushes through the hole in the platinum above, and draws air in under the platinum plate, thus keeping the point of ignition cool and preventing the formation of carbon. All acetylene burners supplied now have provision made for an extra supply of air for the burner by means of holes, which are usually drilled in opposite sides of the burner, as shown in fig. 1009, and in such a manner that the air plays immediately upon the flame and cools the burner at the lighting point at the same time.

Dr. P. Wolff (*Zeitschrift für Beleuchtungswesen*, 1898, p. 24) states that with a Bray's burner, No. 0000, burning acetylene at the rate of 1·377 cu. ft. per hour under a pressure of 23½ tenths of water, he obtained the result of 273 candle power when consuming the gas at the rate of 5 ft. per hour; but the burner mentioned is not effective after a few hours, owing to its liability to carbonize at the points of ignition. This was one of the early types of burner, but other burners now made by the same firm, such as the Leta, are on similar lines to that shown in fig. 1008, and do not readily carbonize

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CHAPTER VIII

OIL GAS

Oil gas has a **high illuminating power**, and is manufactured from Russian solar oil and the Scotch gas oil. It is used principally for the lighting of railway carriages, lifebuoys, and lighthouses, and is also sometimes added to common coal gas of low value to increase its luminosity. The gas is supplied in cylinders under a pressure of about seven atmospheres (105 lb. per square inch). The illuminating power is originally 70 to 80 candles, but when the gas is subject to this compression tarry matter is condensed out of it, and the illuminating power is reduced to from 50 to 38 candles, when measured while burning at the rate of 5 cu. ft. per hour. If, however, acetylene to the extent of 20 per cent, and oxygen to the extent of 15 per cent of the volume of the oil gas are added to it before compression, its illuminating power is about doubled, whilst its permanency is not affected.

The composition of oil gas of two kinds is given below, the analyses having been made by Professor Vivian B. Lewes.

	Pintches' System.		Young's System.
Unsaturated hydrocarbons, ...	35·65 per cent	......	43·83
Saturated „	45·37 „	......	36·30
Hydrogen, ...	12·41 „	......	16·85
Carbon dioxide, ...	·74 „	......	·63
Carbon monoxide, ...	·60 „	......	
Oxygen, ...	2·00 „	......	1·14
Nitrogen, ...	3·00 „	......	1·25

In **Pintches' system of manufacture** double retorts are employed, one placed upon the other. The oil is run on to a tray at one end of the upper retort, and passes along, being vaporized the while, to the other end, and thence into the lower retort, which is of similar shape and size. The retorts are about 6 ft. in length and about 10 in. wide and high, and are made of cast iron. The gas formed in the upper retort is subjected to a high temperature (about 1800° F.), which makes it permanent. At this temperature the iron becomes bright red. The amount of oil "cracked" or converted from the liquid to the gaseous state is about 2½ gal. per hour for the two retorts, and should richer gas be required, more oil is permitted

to flow into the first retort. The amount of gas obtained per gallon of oil is rather over 80 cu. ft., and about one-third of the volume of oil used is deposited as tar. Other systems of oil-gas manufacture are largely based upon the principles and method followed in Pintches' system.

Burners.—Much difficulty is experienced in obtaining the full value of this gas when used as an illuminant. Ordinary burners are useless owing to their permitting so much smoke, which indicates that the air supply is not what is required. The Coligny-Welch lamp is generally used for railway carriages. It is fitted with a circular burner, capable of consuming from $\frac{3}{4}$ to 2 cu. ft. of gas per hour, and has an efficiency of about 13 candles per foot. The most suitable flat-flame burners for oil gas are Bray's Nos. 000 to 00, which work well at a pressure of $\frac{5}{10}$ to $\frac{6}{10}$ in. When a percentage of acetylene is added to oil gas the smaller burner will be found the more efficient.

CHAPTER IX

AIR GAS

Although acetylene gas has been largely adopted for the lighting of country houses where no public supply of electric current is available, it is now being replaced by a newer illuminant known as Air Gas, which is free from the principal defects of acetylene and seems destined before many years to completely supersede it.

Air gas, so called from the large proportion which the ordinary atmosphere forms in its composition, consists of a mixture of approximately $98\frac{1}{2}$ parts of air with $1\frac{1}{2}$ parts of petrol vapour. It has been known for some time that a combination of these proportions results in an inflammable but non-explosive gas, but it was not until recently that means were discovered of ensuring a constant supply at a uniform strength. Several machines by which these ends are successfully attained are now on the market, and, broadly, are of two types—motor-driven and weight-driven. The principal objections to the former type are that about 10 or 12 per cent of the gas produced is consumed in running the engine, and that unless a somewhat expensive gasholder is provided it is impossible to obtain a light after the motor has been stopped for the night. Of the weight-driven type, one of the most successful machines is that made by the Premier Lighting and Engineering Company. A weighted wire cord wound around a drum revolves an axle on which are three eccentric wheels operating an air pump by means of endless chains; air is driven through three valves into a vaporizing chamber where it combines with petrol vapour supplied through a carburettor. The air gas thus formed passes into a small gasometer, the rising of which automatically applies a brake to a flywheel on the axle, so that as the storage increases the action of the machine is retarded or stopped, starting again when gas is drawn off at any of the fittings. The petrol tank may be fixed quite outside the

building for purposes of fire prevention, and so long as this tank is supplied and the weight properly wound up, a regular supply of gas is assured.

Containing as it does so large a quantity of ordinary atmosphere, air gas does not take up any appreciable amount of oxygen from the room in which it is burnt; it contains no carbonic oxide or sulphuric acid, and is innocuous to plants and decorations, and being free from deposit it does not corrode the pipes or burners. The gas has a distinct and rather pleasant smell by which a leakage can be readily detected, it is non-poisonous and non-explosive, and is the most economical illuminant on the market.

Section XIV.—GLAZING

BY

J. EUSTACE SALISBURY

SECTION XIV.—GLAZING

CHAPTER I

HANDLING, CUTTING, AND PACKING GLASS

Handling.—Glass is of such a brittle nature that it is an easy matter to endanger both limb and life by the handling of large sheets in a wrong manner. In carrying a large sheet of glass on edge horizontally, the hands should never be placed opposite to each other (No. 2, Plate XLIII), as in this case a slight swerve of the body, or a sudden gust of wind, may easily result in a catastrophe. It is best to have the hand holding the lower edge as far forward as possible, and the other holding the top far back; thus the sheet will be supported near the ends and the weight distributed. If this plan is followed (No. 1, Plate XLIII), both hands will share the burden.

In lifting sheets of glass from the ground on to the bench, they should be swung with both hands by the top edge till the lower edge rests on the far side of the bench, and then allowed to fall on to the outspread palms. No. 3, Plate XLIII, shows the act of swinging the sheet on to the bench in the manner just described, while No. 4 shows the glass dropping on to the hands before being laid on the bench. If this action is carried out rapidly, it will be found that the resistance of the air will support the falling sheet equally, so that expert cutters will let a sheet 10 ft. long fall from its edge on to the bench, just spreading their hands out at the last moment, and swiftly withdrawing them when the glass comes close to the bench.

Common sense will dictate that the sheet must not be carried vertically, unless the hands are placed well above the middle of the sheet. It is safest to hold it as near the top as possible, so that if there happens to be a flaw in the glass, or any breakage occurs, the fragments will fall direct to the ground instead of on the workman, as would be the case if much of the sheet were above the level of his head. Nos. 5 and 6, Plate XLIII, show the right and wrong methods of carrying glass vertically.

For raising sheets of glass to a considerable height above the ground, a crane or pulley must be employed, and a carrier or sling used, composed of a flat piece of wood about 4 in. wide, with two hooks about 6 in. or 1 ft. from each end (fig. 1010), to prevent the ropes from slipping together.

A guiding rope is also necessary to keep the sheet from gyrating, and this should be attached to one end as shown in the illustration.

With very thick or heavy pieces of glass, that require more than one workman to carry them, the weight should be allowed to rest entirely on the lower hands, whilst the upper hands merely hold the glass loosely to keep it vertical. If this method is followed, all contrary strains will be avoided; but if, in attempting to lift it from the carrier, the workmen take the weight evenly in both hands, contrary strains are at once set up, and there will be danger of breaking the glass.

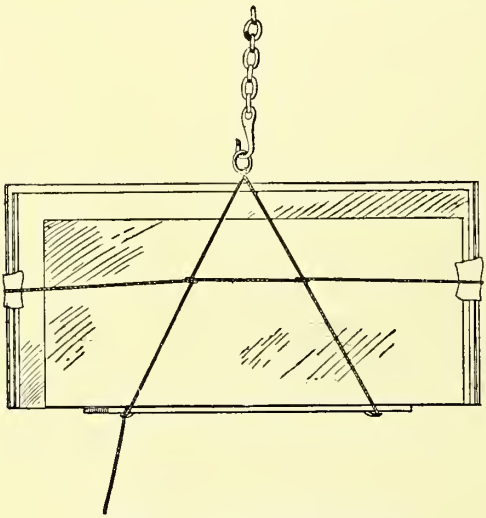


Fig. 1010.—Carrier for Sheets of Glass

The same rule applies to squares of unwieldy size, such as those for large shop windows. In this case, however, cords will be used, furnished with pads on which to rest the glass, and held by one man on either side; as many cords as are deemed necessary being placed at equal distances along the sheet, whilst a workman at each end holds it in a vertical position. If the sheet is too large to be held upright by two men, a rope must be passed twice round the upper part (fig. 1011), and another cord attached to it on either side of the centre; in this manner the very largest sheets procurable can be handled with perfect safety, but it is seldom found necessary to resort to this method, as the maximum size of ordinary plate glass is about 9 ft. by 13 ft.

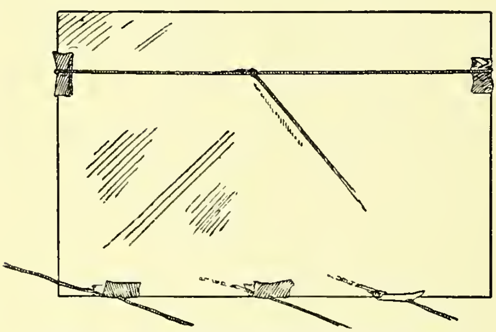
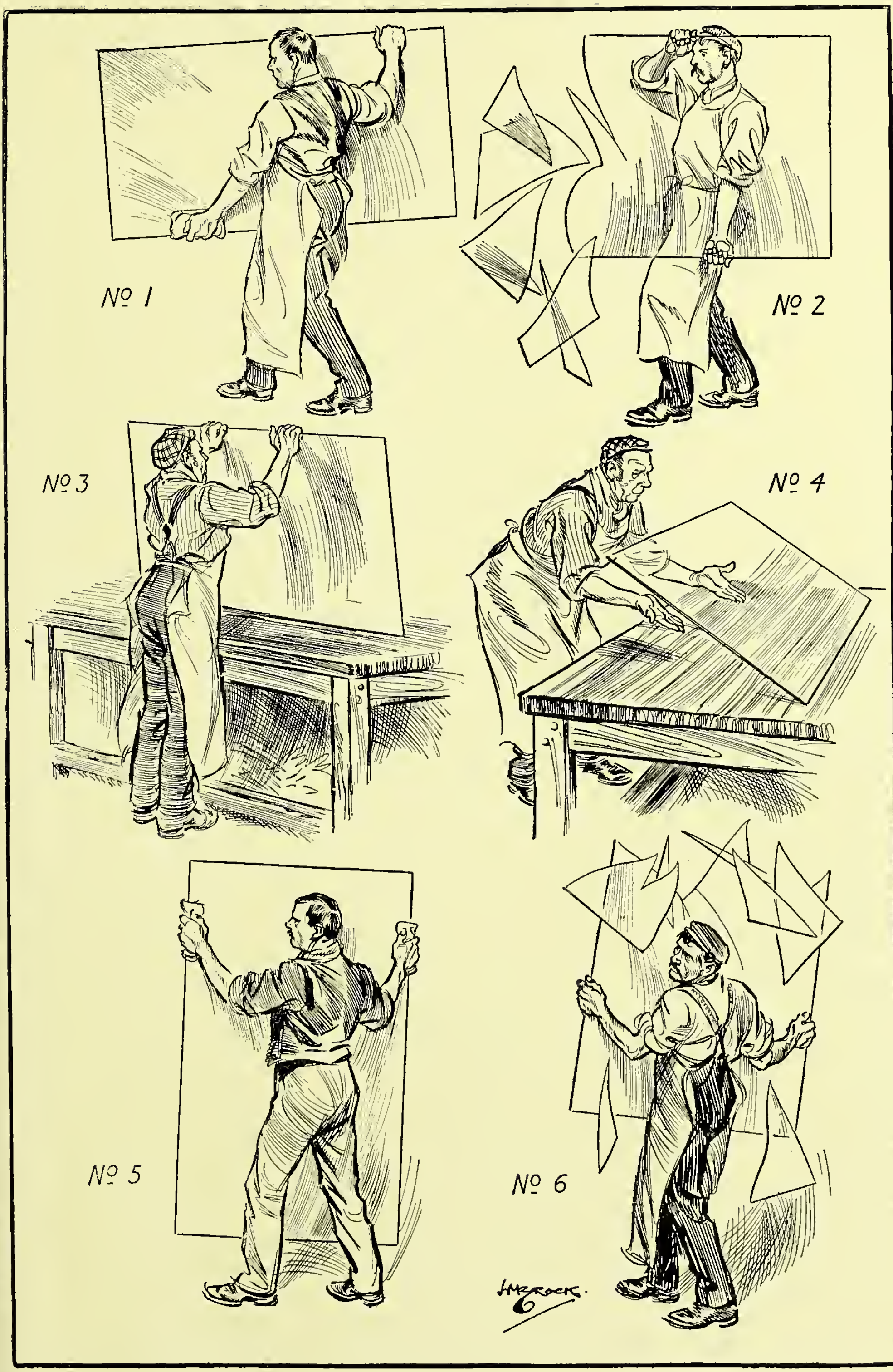


Fig. 1011.—Method of Carrying Large Sheet of Glass

Cutting.—Glass is cut into the required shapes and sizes by means of a diamond. This tool will cut the glass properly when held in one position only as it is drawn across the sheet; if this position is varied in the slightest degree, a white scratch is made instead of a clean cut. An unmistakable difference in the sound will indicate when the glass is being properly cut and when merely scratched; in the former case a clear musical sound will be emitted, whilst in the latter a noise that will jar upon the ear. To cut well the diamond must be held firmly between the fore and middle fingers, and then quickly passed over the sheet at the same angle throughout. If broken at once, before the cut has had time to cool, the glass will part



RIGHT AND WRONG METHODS OF HANDLING GLASS

quite easily along the line of the cut, and, when once the knack has been acquired, the more rapidly the cutting process is done the better.

A diamond is the only tool that will satisfactorily cut sheet or plate glass, but in the case of the softer kinds of glass, that are used for leaded lights, a wheel cutter will be found fairly satisfactory, and is in common use in leaded-glazing workshops.

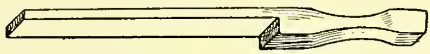


Fig. 1012.—Wooden Gauge

When many squares have to be cut to the same width, a wooden gauge should be made of the shape shown in fig. 1012, by means of which the cutting of repeated sizes will be accomplished with rapidity and accuracy.

When a number of small "squares" of the same length are required, the work is facilitated by a cutting board (fig. 1013), having a hard wooden lath fixed to the near edge, and a cross lath at right angles as shown. Attach the board to the bench, and fix a hard wooden block to the bench at the distance from the board required for the exact length of the square;

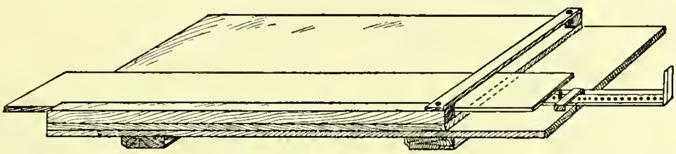


Fig. 1013.—Cutting Board for Glass

this should form a stop to the glass when it is pushed under the cross lath. Take one of the ranges previously cut to the required width by means of the gauge described above, and cut off the part necessary to render it square; then push it along to the stop and pass the diamond along the right edge of the cross lath; now press on the square to break it off, and put it on one side; pass the range of glass forward again to the stop and cut as before, and repeat the process until the required number of squares have been cut.

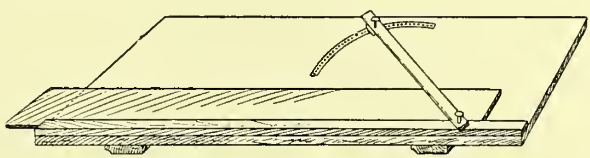


Fig. 1014.—Cutting Board for Diamond-shaped Panes

Diamond-shaped panes are cut on the same principle, the only difference being that the lath is set quite accurately to the required angle (fig. 1014), the stop being set so that the glass will be cut the same length as the width of the range. The lath can be adjusted to any angle by means of the thumb screw and the holes in the perforated quadrant, which is let into the board.

Glass should be cut on a perfectly level bench covered with baize.

The cutting of curved and irregular shapes can be accomplished in two ways: either by having a piece of cardboard cut out to the required form, and by running the diamond round it when it is placed on the glass to be cut; or by the aid of a small lath brought round the shape in

little movements alternating with the movement of the diamond (fig. 1015). When the shape has been completely marked round with the diamond, begin at the place where the cutting started and tap the glass gently on the under side until it begins to fly along the cut; follow it on, keeping a little ahead all the time. If it is a gentle sweep it will break off immediately, but

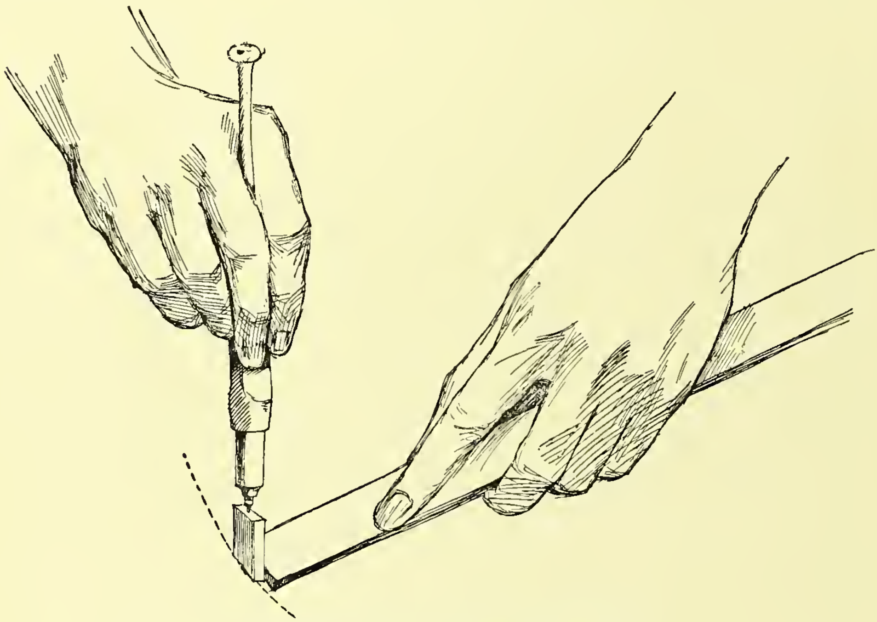


Fig. 1015.—Cutting Curved or Irregular Pieces of Glass

if it is a very awkward and irregular shape, the glass to be broken away should be cut again in diagonal lines converging into the original cut.

It is sometimes required to cut a hole out of a square of glass, leaving the rest intact. The old glaziers often did this in their ornamental heraldic glazing, sometimes, indeed, having a succession of these cut-away parts in one piece of glass. In many cases these were done by drilling a series of small holes. Another method was to make a small cut with the diamond, then to press a small pointed and heated poker over the diamond cut and work it round until the complete circle had been described. The poker was then heated again, and the former process continued until the glass began to split at the diamond cut. The slit was then followed round, the poker being held an eighth or a quarter of an inch in front; and when the glass had been slit all round the piece dropped without any difficulty. This method is a little tedious and not always sure, but its great advantage is that it saves the tapping underneath, which sometimes causes breakages.

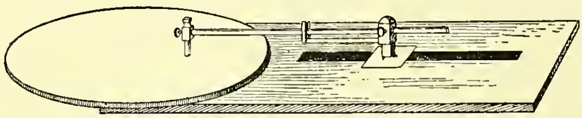


Fig. 1016.—Turn Wheel and Diamond for Cutting Circles

True circles can be cut on a turn wheel (fig. 1016) mounted with a diamond. With these little machines, which can be procured from a number of well-known firms, a circle can easily be cut, leaving the square whole. Fig. 1017 shows a kind of beam compass which is used for the same purpose; the beam A, on which the diamond is fixed, can be moved backwards and forwards, according to the size of circle required to be cut, and is fixed by the thumb screw at B.

When it is required to cut true arcs, another contrivance will be found to be useful, and especially does this apply in the case of narrow parallel curves struck from the same centre. A lath or strip of wood (fig. 1018) should be procured of the length necessary to compass the distance from the centre to the circumference; burn one or more small holes near one end of the lath, and drive a nail through one of these directly above the centre of the circle; cut notches in the lath where the glass has to be cut; place the diamond in one of the notches and sweep the lath round with the left hand, still keeping the diamond in the notch.

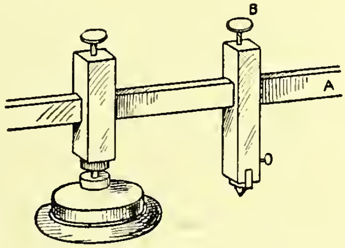


Fig. 1017.—Beam Compass for Cutting Circles

Packing.—In packing glass it is a mistake to suppose that the quantity of straw placed between the sheets increases the safety of the glass in transit; on the contrary, the reverse rather holds good, because when a large quantity of packing material is used, it is difficult to get it evenly spread. When packing glass, a box or crate should be chosen of the size required to take the sheets. The bottom should be filled evenly with a bed of hay or straw about 2 in. deep, the sides being lined with straws, placed vertically, about 1 in. in thickness, or, if preferred, hay will answer exactly the same purpose, if care is taken to have it evenly spread. On this bed the first sheet of glass should be laid. On a very

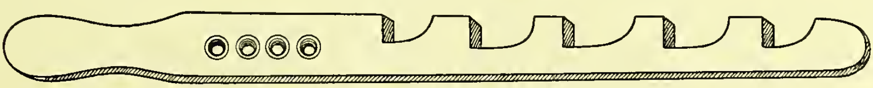


Fig. 1018.—Lath for Use in Cutting Concentric Curves

thin layer of hay, or a layer of single straws, lay the next sheet, and proceed in the same manner until all the sheets are in, when the spaces still left in the box must be filled tightly between the glass and the side of the case, the straws or hay for this being inserted longitudinally in small portions, each portion being pushed in equally with a lath. This packing having been wedged in so that there is absolutely no movement of the glass apart from the case, even when it is vigorously shaken, then proceed to fill up the top with as much packing as possible, and nail down with pieces of wood placed crossways, or with a single board exactly fitting the packing case.

The whole secret of glass-packing is to wedge it in so tightly and evenly that it cannot slip inside the case in the slightest degree.

CHAPTER II

KINDS OF GLASS

Sheet glass is made in four qualities for window glazing, viz.: Best, seconds, thirds, and fourths. It will be noticed in foreign glass that the brands vary to such an extent that the sheets of the fourth quality in one will be almost equal to the thirds of another. The fourth quality of sheet glass is full of waves, specks, and other flaws, and is seldom used except in jerry-built houses and in the cheapest kinds of leaded lights.

The various thicknesses of sheet glass are distinguished in the trade by their approximate weights per superficial foot, such as "15-oz. glass". The corresponding weights and thicknesses are as follows:—

$\frac{1}{14}$ to $\frac{1}{12}$ in.	thick	weighs	15 to 16 oz.	per superficial	foot.
$\frac{1}{10}$	,,	,,	21	,,	,,
$\frac{1}{8}$	,,	,,	26	,,	,,
$\frac{1}{7}$	,,	,,	32	,,	,,
$\frac{1}{6}$	,,	,,	36	,,	,,
$\frac{1}{5}$	,,	,,	42	,,	,,

Tinted and pot-metal sheet glass is not much in demand at the present time, but it can be procured in 16-, 21-, 26-, and 32-oz. qualities. In the case of pot-metals or deep colours, sanded sheet-glass has taken the place formerly held by the plain, because of its superior effect. Pale-green tinted sheet glass has a much better effect than ordinary white sheet, and especially will this be found to be the case in leaded light work.

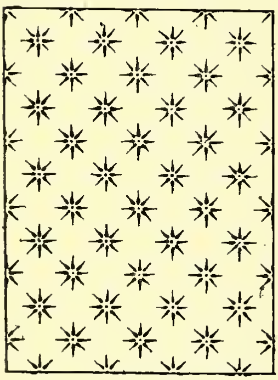


Fig. 1019.—Enamelled Glass

Ground glass is made of substances similar to those employed in the manufacture of plain sheet glass, the difference being that in the former case one side is roughened by being ground with emery powder.

Enamelled glass (fig. 1019) is made in 15-, 21-, and 26-oz. qualities, and in an endless variety of patterns, and is simply embossed sheet glass, having the raised parts ground. The embossing is accomplished by the application of fluoric acid, after the pattern has been traced out with Brunswick black or other acid-proof composition. This glass is sometimes ground on the reverse side to render it absolutely obscure.

Embossed plate glass is usually made to order, and is similar to the embossed glass just described, but of a higher quality, the pattern lettering or border being worked upon plate glass instead of sheet glass.

Polished plate glass is obtainable from $\frac{1}{8}$ to 1 in. in thickness, the quality that is mainly used being the $\frac{1}{4}$-in. This glass is cast between metal plates, and ground to an even surface and then polished, one sheet being utilized

for the working of the other. That known as "silvering quality" is regarded as the best.

Crown glass is now seldom used, though, if large quantities are ordered, it can be obtained. The method of manufacture is interesting. The glass is first blown into a spherical bulb; it is then removed from the "puntil" on to an iron rod, which has been heated in a furnace, and on which, by a rapid rotatory movement, it is whirled out into a flat circular disc or sheet. This method produces a knob or crown of glass at the centre of rotation. Knobs of this kind are still to be seen in the windows of old houses, and now go by the name of "bullion". Crown glass is necessarily slightly convex, and this gives an excellent appearance to the window into which it is glazed. The glass can usually be distinguished by the concentric rings or ripples on the surface. Messrs. Chance Brothers are the only firm manufacturing crown glass at the present time.

Patent plate glass is sheet glass polished on both sides, and is supplied in the following qualities—best, second, and third. The thicknesses are $\frac{1}{16}$ in., $\frac{1}{12}$ in., $\frac{1}{10}$ in., $\frac{1}{9}$ in., and $\frac{1}{8}$ in.

Rough plate glass is supplied $\frac{1}{8}$ in., $\frac{3}{16}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. in thickness, and, as its name suggests, its surface is uneven. When it is fluted longitudinally it is often known as "Hartley's rolled plate".

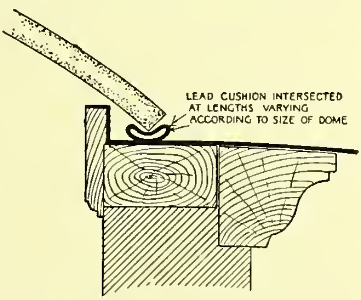


Fig. 1020.—Dome of Rough-cast Plate Glass

Rough-cast plate is a very similar glass, and may be described as unpolished plate glass of inferior quality. It is supplied in thicknesses from $\frac{1}{4}$ to 1 in., the greater thickness being mainly used for pavements, roofs, and skylights. This glass is also made in spherical domes in one piece, in sizes from 1 to 7 ft. in diameter. The advantage of using these is that a perfect skylight can be obtained when they are properly set. As the glass is in one piece, the sun and weather can in no way affect it, and, moreover, being domed, the condensation falls to the extreme edges, where the lead is arranged to allow it to escape (fig. 1020).

Cathedral glass is rolled plate weighing about 26 oz. and $\frac{1}{8}$ in. thick; it can be had white or tinted, and is made in sheets about 3 ft. by 10 ft. or more. It gains its name from the fact that its use is prevalent in churches. It is not a very translucent glass, but its great advantage is that it obscures the definition of objects both within and without. Glass rolled on both sides, and known as "double rolled", is now displacing the dull, single, or cathedral-rolled glass.

Figured Rolled Glass.—In the making of this a patterned roller is employed instead of the plain one used in making cathedral glass. This process lends itself to endless varieties of design (fig. 1021). The patterned rollers are in some cases formed by pyramidal outlines, which, when pressed upon the surface of the glass, form a multiplicity of prisms, which refract the light in all directions, so that even the shape of an object in the strongest light and shade is hardly distinguishable. At the same time

it allows all the rays of light to penetrate through it. This glass should be fixed with the rough side inwards, so that exterior dust and dirt do not settle on the indentations of the pattern.

Patent wired rolled glass is similar to Hartley's rolled glass, but has wire netting embedded in it. The additional strength thus gained makes it invaluable for skylights fixed at a great height from the ground. It not only resists stones, but will sustain heavy weights of snow, to the increased safety of those beneath. It is valuable as a fire-resisting glass, because the embedded wire holds the glass together up to melting-point. When a fire occurs in a building, ordinary glass is soon broken by the heat, and admits air to fan the flames. Tests made by the British Fire-prevention Committee demonstrated the special usefulness of wired rolled glass as a fire-resisting and fire-retarding material.

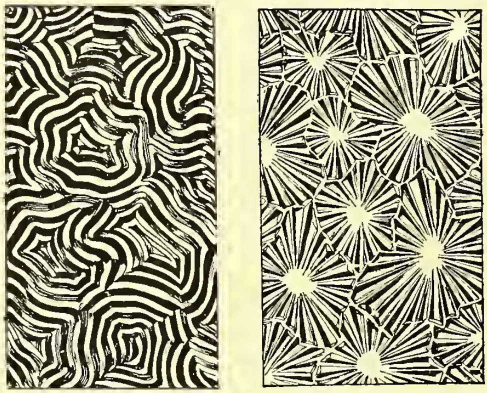


Fig. 1021.—Figured Rolled Glass

Fluted glass is a perfectly smooth ribbed glass made in four thicknesses, 15, 21, 26, and 36 oz. The flutes obscure the definition, but not the object itself.

Muffled glass is also much used as a screen. It has an irregular wavy surface, somewhat resembling a miniature sea, and the varying undulations give it an advantage over the stamped glass, which has so regular and hard an appearance. Muffled glass is obtainable in tinted as well as in white sheets.

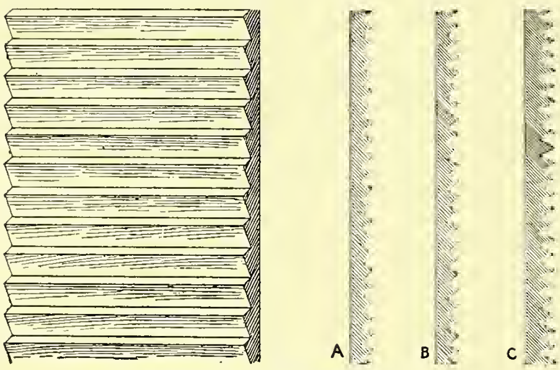


Fig. 1022.—Prismatic Rolled Glass

Prismatic Rolled Glass.—Manufacturers have made use of prismatic forms to refract light in many ingenious ways. Messrs. Pilkington Brothers produce a patent prismatic rolled glass (fig. 1022), which is made in slightly varying angles to suit various conditions of lighting. For basement windows or for shut-in areas, where little sky is visible, this glass can undoubtedly be used with good effect. The angles of refraction are calculated from a line taken from the middle of the window to the point which marks the highest limit of obstruction. Nos. A, B, and C

should be fixed in windows where such an imaginary line most nearly approaches an angle of 50°, 40°, and 30° respectively. This glass is made in sheets as large as 60 by 90 in. The ribs must always necessarily run horizontally, and the panes should be placed with the shorter side of the rib at the top, and with the smooth side outwards, as shown in the illustration.

A glass very similar to that just described is made under the name of "Luxfer" prisms, in 4-in. squares, united by copper electro glazing to form sheets of the sizes required to fit the openings. The same principles of refraction obtain in this glass as in that described previously, but in a stronger degree owing to the slightly larger prisms. By these means light striking into a room from an enclosed area is not absorbed on the floor near the window, but is refracted so as to pass straight into the room (fig. 1023).

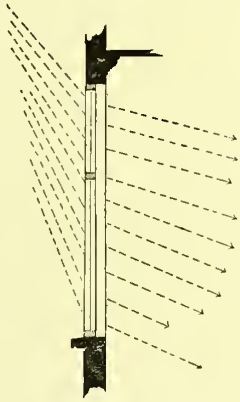


Fig. 1023. – Refraction of Light by Vertical Prismatic Glass

The makers should always be consulted when these prism glasses are to be fixed, as so much depends on inserting the prisms that are specially suited to the existing conditions of light. Where but little sky is discernable, prisms of very strong refractive power should be used, and as the variations in section required here differ so slightly from those required for less-confined spaces, the safest course is to consult those who have made it a matter of special study.

The Luxfer Prism Syndicate, Limited, shows an ingenious use for these prisms where light is confined, as is very often the case, over a lantern light. In No. 1 (fig. 1024) the prisms are fixed on the ceiling line and disperse the rays through the room; but if a still greater dispersion of light is necessary, they can be fixed at an angle below the ceiling line, as shown in

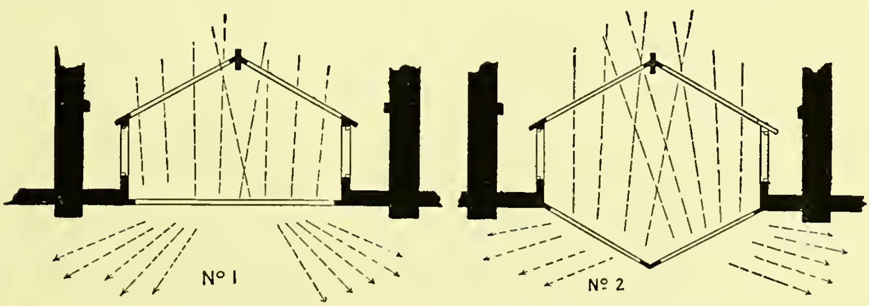


Fig. 1024.—Refraction of Light by Prismatic Glass in Counter Lights

No. 2. The crowded areas of our cities render such contrivances as these necessary, and it is of the highest importance to consider all the new and best means of obtaining the maximum of light in adverse circumstances.

Decorative Glass.—This concludes the list of the different kinds of glass used in the ordinary course of glazing for light-giving purposes, but there are, of course, other kinds which are used principally for obtaining artistic effects. In this category may be included antique Ambetti, kelp, Venetian,

and Flemish glass, opalescent, and Prior's or Norman glass. The last named is actually formed from cutting up square glass jars; the difficulty of doing this without breaking them renders the glass somewhat costly. The other varieties may be classed under the heading of stained glass, and it is not therefore necessary to include them in this treatise.

Opalescent glass has been utilized in a novel way for the covering of bathroom and lavatory walls. For this purpose it is roughed on one side whilst in its molten state, or covered with a rough coating, so it readily and firmly adheres to cemented walls. It can be cut with a diamond to fit into any corners or shapes that may be required, and forms a most sanitary and smooth wall covering.

Glass tiles are made in the same sizes as ordinary tiles and slates, and can be fixed in like manner for such purposes as the lighting of unceiled lofts, &c. The glass tiles should be equal in thickness to the tiles or slates with which they are to "course". They are made in thicknesses varying from $\frac{1}{8}$ to $\frac{3}{8}$ in., and can be obtained with nibs like the Broseley tiles, if desired.

Curved Glass.—Where glazing is required to be done on the curve, a template should be taken of the section of the desired curve, and sent to the glass manufacturer as a pattern for the glass to be bent from.

In the glazing of small leaded squares or quarries, curves over a 3-ft. radius can be produced by gentle pressure while the glass is being leaded together on a cradle shaped to the required curve.

Glass Shelves.—When it is desired to use plate glass for shelving purposes, the edges of the shelf should be ground, and the whole either swung on chains or supported by brackets.

CHAPTER III

HINTS ON ORDINARY GLAZING

Ordinary Glazing.—The simplest form of glazing in wood rebate with putty will always remain in demand, to a certain extent, owing to its cheapness; it will therefore be well to consider one or two things necessary for making it as durable as possible, and also the best ways of carrying out the work. As we have already dealt with the cutting and handling of glass, we will assume that it is cut to the required sizes and ready for putting in.

The putty which is to unite the glass to the wooden bars should never be compounded with any other than pure linseed oil. In much of the modern commercial putty cheap and inferior oil is employed, and the greatest care should be taken that the purest linseed oil only is used. Manufacturers will unhesitatingly send guarantees to this effect if application is made.

The putty as sent from the warehouse is not fit for use, but requires to be basted (on a strong bench made for the purpose) with a heavy mallet

until all the small lumps, and parts that have become hardened by being in contact with the sides of the cask, are all of one even plastic consistency. When this condition has been achieved, the putty may be divided into one-third and two-third parts; the one-third for bedding the glass, and the remainder for front puttying. The putty used for the bedding should be softer than that employed for the front puttying; therefore add to the bedding putty linseed oil, and to that used for front puttying add powdered whitening that has been rubbed through a fine sieve. Work these into the one and the other with the hand and mallet until the right consistency has been obtained.

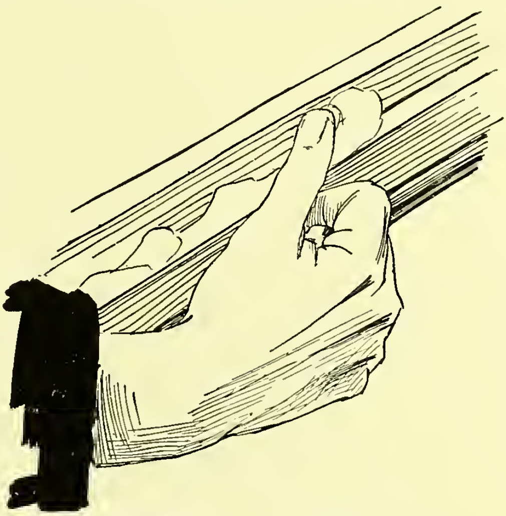


Fig. 1025.—Method of Applying Bedding Putty

The bedding putty must be of a perfectly regular plasticity, and absolutely free from any lumps. If these precautions are not taken, there is a likelihood of the glass being broken; indeed, one of the most important factors of glazing is to have an even bed for the glass to rest on. Take a lump of the bedding putty, and, with the thumb, apply it to the rebate, pushing the bulk of it in front of the thumb, as illustrated in fig. 1025. Having applied the putty in equal quantities round the rebates, lay the glass in position, and bear upon it with fingers spread out to cover as much of the glass as possible, in order that the pressure may be equally distributed; work the putty gently down into the rebates with the outspread fingers, pushing along the surface until the glass is quite evenly bedded.

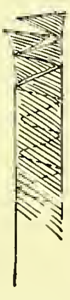


Fig. 1026.—Method of making Zinc Sprigs

Sprigs.—The glass may then be tacked in with small wedge-shaped sprigs, care being taken that it is not pinched unevenly with them, as the glass is bound to crack where it is pinched, sometimes even as much as a week or a fortnight after it has been glazed. In order to avoid this, it is an excellent plan to procure a strip of zinc of a width corresponding to the length of the sprig required, and to cut it into alternating diagonals (fig. 1026), and to use the triangles thus formed in place of bought sprigs; they will drive into the wood rebates quite as easily as the latter kind, and, being pliable, will give with any uneven pressure. These home-made sprigs involve but a trifling extra trouble, and are strongly recommended in place of the others.

Front Puttying.—The next process is the front puttying, which is executed with the stiffer putty already described. This is applied with an ordinary puttying knife, such as that illustrated in fig. 1027, going evenly round the rebate as before; then, holding the knife with the right hand,

and pressing on the blade with a finger of the left hand (fig. 1027), draw the knife along, sloping it outwards to the angle required for the surface of the front putty, and keeping the knife up a little so as to include any unevenness within the sweep of the tool. Fig. 1028 gives a section showing how this form should be when finished. It will be noticed that the front putty is $\frac{1}{16}$ in. back from the sight edge of the rebate.

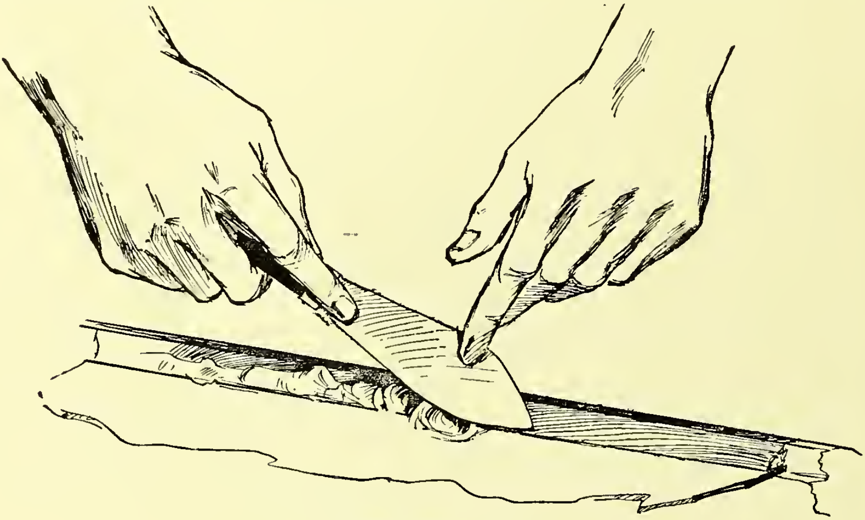


Fig. 1027.—Front Puttying

Finger marks and putty smears left upon the glass can be removed by dusting whitening powder on to both sides of the pane with a brush, and then brushing it carefully off again. The usual practice of the trade is then to dot the panes of glass on the inside with a paste formed of whitening and water. This is done to remind other workmen on the building that the glass is newly put in, it being sometimes necessary to insert the windows long before the other works connected with the building are completed, in order to exclude rain and damp.

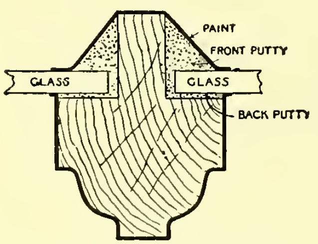


Fig. 1028.—Section of Putty Glazing

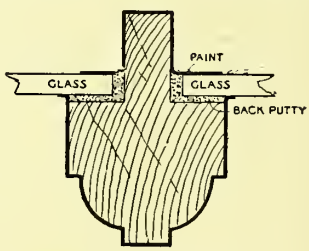


Fig. 1029.—Back Putty and Front Paint for Skylights

Top Lights.—The front puttyings of skylights and roof glazing are very readily attacked by frost, owing to the fact that the moisture cannot drain off windows as rapidly as from a vertical surface. It has therefore been found advisable to do away with the front putties altogether, simply bedding the glass in with putty, and cleaning it off flush with the surface of the glass (fig. 1029). The thick line represents the coatings of paint that are substituted for the front puttyings. The paint, which should be white-

lead paint, will take the place of the front puttying, and this treatment will leave little or no substance for the weather to work upon, and is twice as durable in skylights as the old way of front puttying. It is not, however, usual to adopt this method in upright glazing, as in this case the glass would not be so securely held as by the front putties. For sloping skylights the glass should be carried over the bottom rail, and prevented from slipping by hook-shaped clips of zinc or copper screwed to the rail before the glass is inserted.

The problems constantly before the glazier are how to glaze a skylight so that it will remain perfectly water-tight, and how to carry away the condensation which must of necessity form on glass that is subjected to the double influences of cold from without and heat from within. We believe that this can only be competently dealt with by the patent systems, some of which will be described in Chapter V; but we will endeavour to show the best means of surmounting these difficulties by what may be classed under the methods of ordinary glazing.

One obvious fact is that the quicker we can carry away the water from the putties the better. An excellent idea for doing this in cases where the glass overlaps, as in the majority of conservatory and greenhouse roofs, is to cut the ends of the glass on the curve (fig. 1030). This is a most economical way, as the curve cut for the end of one pane will serve for the opposite end of the next pane. These curved panes should be cut in the way described in Chapter I, and shown in fig. 1014, with this variation, that the cross lath should be cut to the shape of the required curve. Another way of getting over the difficulty is to point the ends of each overlapping pane, as shown at A of fig. 1030. These methods of cutting the ends of the pane not only draw the water from the outside to the middle of the pane, away from the puttyings, but the condensation within is also attracted in the same way, the slight division between the overlapping panes being sufficient to carry the condensed vapour to the outer side of the glass.

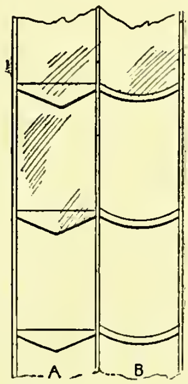


Fig. 1030.—Overlaps in Ordinary Glazing.

Condensation Channels.—In the case of skylights where the glass does not overlap, the condensed vapour must be carried away by means of a small lead or zinc gutter, or by a condensation groove in the bottom rail of the skylight, from which small lead pipes carry the water through the wood to the roof outside. As a general rule the skylight is well above the roof, so that it is usually possible to carry the condensed vapour outside in this way.

Patent putties are the outcome of the difficulties that are encountered in roof glazing, the best and most widely known being called "Plastine", a composition carefully prepared by Messrs. Carson & Sons. It has a much longer life than ordinary putty, and is not so easily affected by the weather; it also sets quickly, which is an advantage, as the weather and frost thus have less chance of disintegrating it.

Horticultural glazing is always a difficult matter, especially as regards

repairs. Glaziers, as a rule, are not sufficiently particular in having the glass and wood thoroughly dry before attempting to reputty; this is of the utmost importance, as the putty will not adhere to the glass so long as there remains on it the least suspicion of moisture. Great difficulty is sometimes experienced in getting both wood and glass into this state, and that is one of the reasons for insisting that for these purposes and for skylights the only really successful and reliable way is the employment of one of the patent glazing methods.

In glazing into iron sashes or casements the most important matter for consideration is the vibration. This may be obviated by giving the glass an extra quantity of putty bed; except for this point, the same rules apply as in glazing into wood. A special putty is, however, used in many cases.

Glazing into Stonework.—In the fixing of glass into grooves in stonework, room should be allowed for a slight settling of the stonework, and the grooves so cut that the glass has a clearance of quite $\frac{1}{8}$ in. on each side. The grooves should be painted, and the glass bedded in white-lead putty tinted to match the colour of the stone. The grooves should be filled with soft putty, the glass being pushed into the deeper groove until it will pass the other jamb or mullion, and then worked gradually back into the shallower groove on the other side of the opening. It must then be worked into the top groove in the same manner, and be wedged at the bottom with lead wedges. Any imperfections in the putty around the grooves and in the rebate at the bottom must now be made good with stiff putty. This will hold it more effectually in position until it has become firmly set.

Glazed Doors.—Where glazing is adopted for doors that are in continual use, and are frequently slammed violently, a soft bed is almost a necessity for the security of the glass, and in these cases washleather is the best material. The washleather must be cut roughly to the size that is required, then a little melted glue must be brushed into the rebates, and the strips of washleather laid in so that they will cover the edge; the glass must then be put in, and the washleather folded over it. Fix the wood beadings over this, so that they hold the glass without pinching it more tightly in one place than another. This can be accomplished most safely with round-headed brass screws. When this has been done, run a sharp penknife around the pane to trim off the irregular ends of washleather flush with the sight line.

For picture-frame glazing patent plate or the "best" thin sheet glass should be used. The glass should be cut slack and secured to the frame with thin strips of brown paper, fastened on so that they are hidden in the rebate of the frame. These keep the dust from working in between the glass and the frame from the front. Remove any particle of dust or dirt from the glass with great care before putting in the picture, and, when this has been done, and the thin back boards inserted and bradded in, the whole should be pasted over with brown paper to prevent the dust from getting in at the back.

Horn and talc are seldom used for glazing purposes, except in special cases, as, for instance, where there is excessive movement or vibration,

as in motor-car screens, &c. It should always be glazed so that the surface is pressed upwards against it, so that it can be rendered absolutely flat, this being a condition as necessary as it is difficult to obtain. One edge must be firmly fixed with very small sprigs driven into the rebate, the same process being repeated on the opposite edges. Press along the wooden mandril or flat surface, and sprig it down at the same time. The ends must be treated in the same way, and finally the beadings must be fixed in as tightly as possible.

CHAPTER IV

LEADED GLAZING

The use of leaded glazing in small squares or quarries first arose from the fact that, in early times, glass was very expensive. To break a large window pane in those days would have been a calamity only put to rights at a great cost, whilst a small leaded pane was much more easily remedied.

The Glass.—For ordinary transparent leaded lights sheet glass is usually selected, but for better work patent plate (that is to say, polished sheet glass) is preferred, as it is entirely free from distorting waves. Where obscured windows are required, cathedral glass and muffled glass are often used. Tinted or stained glass is not as much used for domestic work as it was some years ago, and elaborate stained-glass windows are beyond the scope of this work. For simple lights, with rectangular or diamond-shaped panes, the squares can be conveniently cut by one of the methods described in Chapter II.

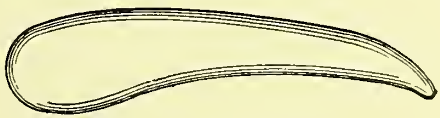


Fig. 1031.—Lathakin (half real size)

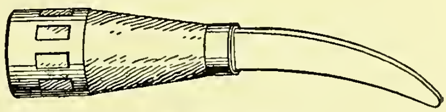


Fig. 1032.—Stopping Knife

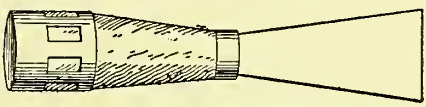


Fig. 1033.—Cutting Knife

Tools.—As lead glazing is a time-honoured craft most of the necessary tools are of shapes and forms that have been handed down from generation to generation. The lathakin (fig. 1031), so curiously named and shaped, is used for opening the wings or leaves of the lead strips or cames, so that the glass can be inserted. The stopping knife (fig. 1032) is used for shaping the ends of the leads, and for turning back the leaves of the outside leads, &c. The cutting knife (fig. 1033) is a thin, sharp, chisel-bladed tool for cutting the ends of lead. As a rule the two last-named tools are weighted in the handle, so that they can be used for tapping in the nails which hold the glass and lead temporarily in place. Any kind of nails can really be used for this purpose, but perhaps the most convenient will be found to be $1\frac{1}{2}$-in. or 2-in. last nails.

Fig. 1034 shows the soldering iron, or, more correctly speaking, the copper bit, which is used for soldering the leads together at their intersections. Gas is supplied through a flexible tube attached to one end, and is regulated by the tap to any degree. With this instrument the soldering can be effected

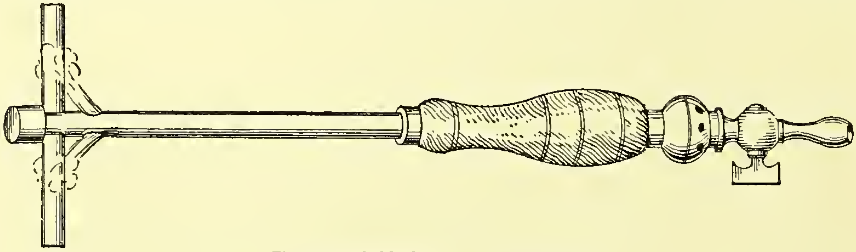


Fig. 1034.—Soldering Tool or Copper Bit

with great rapidity. The modern workman, with this splendid little tool at his command, can pity the glazier of olden times, who had to solder one or two joints and then wait until the copper bit could be reheated. The reel, shown in fig. 1035, is used for shaping the leads for roundel glazing, the came being twisted round this mandril to the size of the required circle. At every three or four turns the coils should be cut through, by taking them off the reel and placing them flat upon the bench, when they can be cut through perpendicularly with the cutting knife.

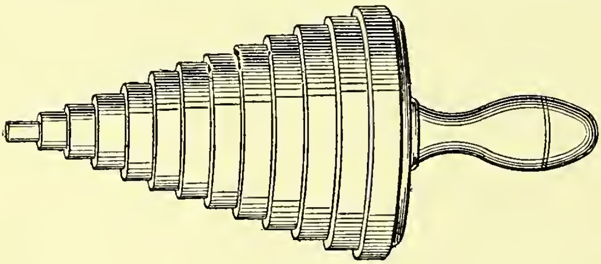


Fig. 1035.—Reel

Lead Cames.—The strips of lead used for uniting the different pieces of glass are known as "cames", and are made by first of all casting into a mould pieces of lead which are much larger in section than is needed; these are next pressed through a machine, from which they emerge in long pliable lengths of lead. Different sections are obtained by using variously-sized cheeks and wheels, which can be changed as desired. Fig. 1036 illustrates various sections of lead cames. A, B, and C are generally used, and can be obtained in sizes which range in width (*i.e.* on the face) from ¼ in. to 1 in.; in A and C the face is convex; in B it has beaded edges. D is an old section with narrow heart, which is now only used as an outside or marginal lead; the narrow heart allows suitable room in the groove and rebate, and the leaf, being thin, can easily be turned back, or trimmed off, if necessary. Sections E and F are used where thick glass such as Prior slabs, Venetian, Antique, or thick plate is employed

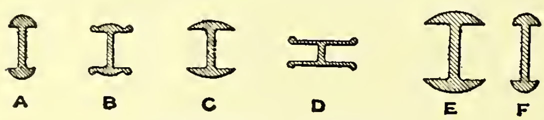


Fig. 1036.—Sections of Lead Cames

The wider heart of modern lead cames allows room for a proper quantity of cement to set the glass. Most of the modern sections of lead are also made with stout leaves that retain their position, so that time is not lost in opening them to insert the glass, and the saving thus effected is more than sufficient to pay for the extra metal.

Before the cames are brought into use they need to be stretched, because, when pressed out of the mill, they invariably curl a little spirally. This stretching is accomplished by placing one end under the foot and drawing the came upwards with a pair of pliers, twisting it round in the process, so that at the last stretch it is perfectly straight; when this is once done the came will remain straight. It can then be placed on the bench and trimmed off at the ends, when it is quite ready for use.

Glazing.—Assuming that the glass has already been cut, the first thing to be done is to spread the "cut line"—that is, the full-size drawing of the centre lines of the lead cames—upon the bench, and to place thereon two oak laths, about $\frac{5}{8}$ in. by 2 in., at right angles, one being parallel with the near edge and the other with the left-hand side of the drawing. Next take two cames, similar to the section D, fig. 1036, and $\frac{3}{8}$ in. or $\frac{1}{2}$ in. wide, according to the size of the rebate or groove in which the glass is to be fixed; push the one into the leaf of the other and lay them against the oak laths, and secure temporarily with a nail. Proceed to insert the glass and the intermediate cames (say of section B, fig. 1036), working from left to right and pushing the cross leads well into the leaf of the outside lead, and cutting them back from the other end of the glass sufficiently to allow the heart of the next vertical lead to touch the glass and to neatly abut against the cross leads; proceed in this manner until the cut line is covered. Finally, put round the two remaining outsides lead cames of similar section to those used in the first stage, then tack on two additional laths to complete the rectangle, truing the whole up carefully and correctly with the square.

The joints must then be greased with stearine wax, mixed with a little linseed oil to soften it, and soldered with the iron shown in fig. 1034. The laths may now be taken up, and the leads on the reverse side trued up where necessary, and soldered.

The cementing is a most important item in leaded glass, and the greatest care should be taken with this, otherwise the work will not be air- and water-tight. The practice of cementing in early times was of a very primitive character. The work was simply brushed over with linseed oil, rubbed with whitening, and straightway polished with lampblack. This method has been greatly improved on. Care must be taken, in the first place, to see that the cementing material is good, and that it is properly prepared. The whitening must be powdered and finely sieved, then saturated with pure linseed oil, terebine being added to make it set quickly. The mixture is always the better for the addition of a little red lead, but it must be borne in mind that if too much of this is used, difficulty will be experienced in repairing a broken square at any time. Lamp or vegetable black should also be added to make the mixture the same colour as the lead.

Directly the work leaves the bench it should be cemented without delay, so that it may have as long as possible to stand and set. The cement, mixed in the way just described to a thick paste, is applied with a short stubbing brush, which is then worked backwards and forwards and round and round until the cement has penetrated right into the heart of the lead. This must be done on both sides, and then rubbed over with whitening and the palm of the hand. The work should be allowed to dry for four or five hours, and then a pick must be run round the edges of each pane, the work brushed with a hand brush, and left to set, and before it is finally packed the windows should be polished with black lead.

Much of the unsatisfactoriness of leaded glass is due to the work being handled and battered about in cases before it has sufficiently set. This causes the cement to ooze out to the edges of the cames, which are invariably cleaned off to make the work look neat; thus the glass, instead of being embedded in a solid setting in the lead, is insecurely fixed. The principal secret of rendering leaded work air-tight and water-tight is to allow it to stand at least a week to harden properly, and as much longer as can be allowed before it is removed from the workshop.

Fixing.—In fixing a sheet of leaded glazing into grooves in stonework the outer leaves of the outside cames must be opened out and tafted back on to the inner leaves, and the sheet must then be evenly worked into position by a series of gentle pats given with the whole palm of the hand. Sometimes it will be necessary to ease it with a knife inserted between the light and the mullion of the window, but the knife must only be inserted where cross leads meet the outside lead. If the sizes have been accurately taken, the gentle tappings will work the glass gradually into its place, and if done patiently, there is little fear of breakage.

The stopping knife is then used for turning back the leaves of the outside leads into the grooves. In stone grooves the light must be held firmly in its place with leaden wedges of the required thickness, driven in gently at the cross leads only. The mason then stops the joint with Portland cement, matched to the colour of the stonework.

When the lights are to be fixed into wood rebates from outside, they should be bedded in putty and fixed by sprigs driven in only at the cross leads, after which the beading or front putty can be put on as in ordinary glazing.

Saddle-bars.—Leaded glass is not sufficiently strong to maintain itself vertically without support; it is therefore necessary to brace it with iron bars placed about a foot apart. The latest method is to secure these to the leaded glass by means of copper ties which are sweated on to the solder joints of the lead work, the two ends being twisted together round the bar when the work is fixed. This method is not really so good as the old, which was to employ narrow strips of lead about ¼ in. wide; these were lapped over each other round the bar, and soldered. The lead tie takes a broader hold on the light, is not so liable to be pulled off, and looks very much better.

Stanchions or upright bars are often used, and these are secured to the leaded lights in the same way. In old cottages they are sometimes to be

found made of wood, 1 in. square in section, and are set into the frame diagonally. In larger houses they were usually formed of iron of the same or of larger dimensions, and sometimes they were fixed to the cross bars. In the latter instances, however, they were employed more as a means of defence than for the purpose of holding the lights in place.

Steel-cored Lead Cames.—An ingenious invention has been brought out by the firm of Messrs. Gibbs & Sons to do away with the necessity for saddle-bars. A small steel rod, sheathed in the window lead (fig. 1037), is the contrivance that, with

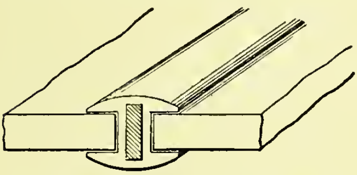


Fig. 1037.—Steel-cored Lead Came

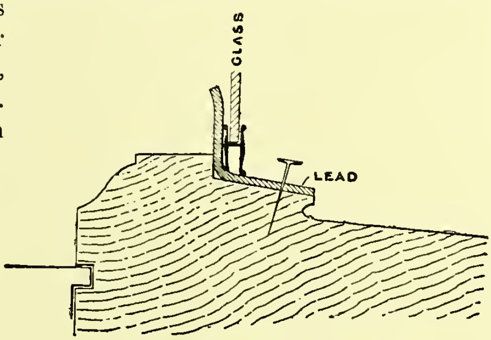


Fig. 1038.—Condensation Channel

economy of labour, strengthens the leaded window sufficiently to obviate the necessity of iron bars. The work should not be entirely glazed with steel-cored leads, but a sufficient number should be introduced to give the necessary rigidity.

Condensation Channels.—It is always advisable to provide means for carrying away the condensation from windows, instead of allowing it to

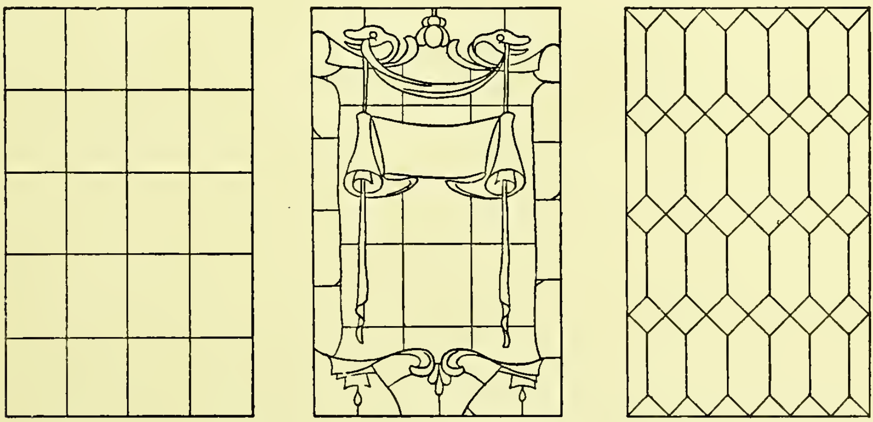


Fig. 1039.—Three Examples of Leaded Glass

remain on the window-sills inside with such deleterious results. In the majority of good examples of old glazing the sill was covered on the outside with sheet lead, which was carried through and turned up vertically inside about 1 in. in height. This method is shown in fig. 1038.

Examples of Leaded Glazing.—In fig. 1039 three examples of leaded glazing are given. There is practically no end to the possibilities of

beautiful treatment in this kind of work, but great care must be taken to keep the lines as simple as possible. It must be remembered that the light comes through the leaded panes, and therefore the lines are constantly being pressed upon the eye. However appropriate elaborate and intricate designs may be in the case of stained glass, it is out of place in an ordinary window, which is intended not only to admit the light, but also to allow the outer world to be seen from the inside of the room.

CHAPTER V

SPECIAL GLAZING METHODS

Many new forms of glazing have been devised for the purpose of superseding putty, which, especially in the cases of skylights, greenhouses, conservatories, and glass roofing, so easily perishes. The continual action

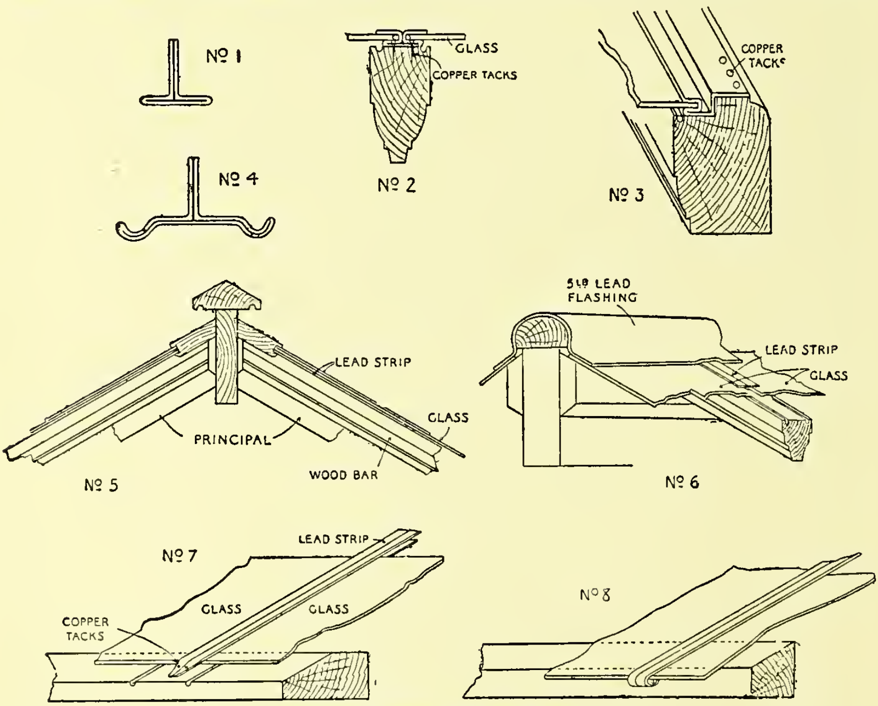


Fig. 1040.—Simplex Glazing System

of heat from within and cold from the outside, playing upon the putty, very speedily disintegrates it.

One of the simplest and best forms is that made by Messrs. Grover & Co., and is really leaded glazing in a new form. It is generally known as the **Simplex glazing system**, and the notable feature of it is the lead strip (No. 1, fig. 1040), which can be supplied in lengths up to 18 ft. This strip

is nailed with copper tacks to the wooden bar of the sash, as shown in No. 2. In the case of end bars the inside only has to be nailed, whilst the other leaf is dressed into the rebate (No. 3). Having fixed the lead strips to the bars, the rebates so formed should be coated with thick paint, preferably a lead paint, the glass being then inserted and the vertical leaf turned down on to the glass with a lathakin (*i.e.* a small lath). This is generally supplied with the strips, and is a piece of hard wood, or bone, with boat-shaped ends. The condensation groove can be in the lead as shown in No. 4, or formed on the wooden bar. The former method is better from the point of view of durability, but it sometimes means that a thinner bar than is required must be used, or that, on the other hand, there must be a waste of lead. The ends of the strips at the top may either be inserted $\frac{1}{8}$ in. into the rail (No. 5) or may be covered with a leaden ridge cap as shown in No. 6. In cases where the glass is set back from the sill, the end of the strip must be dressed down flat and nailed (No. 7). Where the glass overhangs the sill the lead strips should be cut about 1 in. too long and neatly curled underneath (No. 8). A safe distance to leave between the bars for this kind of glazing is 18 in.; there is no advantage obtainable in having it more than this, and bars 15 in. apart and even less are frequently used.

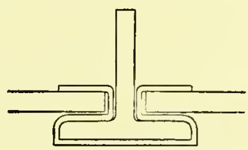


Fig. 1041.—Simplex Glazing System with Iron or Steel Bar

This method is also applied to iron or steel bars, of which fig. 1041 shows a full-sized section, viz., an iron T bar sheathed with lead in such a manner as to allow the lead to fold over the glass as before, giving the necessary strength for a big span in a compact and neat form.

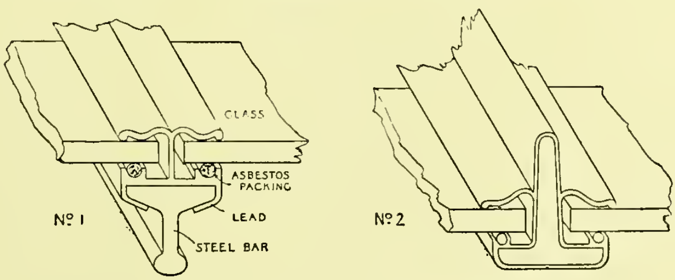


Fig. 1042.—Heywood's Glazing System

No. 1, Ordinary Bar; No. 2, Lead-clothed Bar

In **Heywood's system** this method can be carried still further, there being condensation grooves and in an additional groove is laid asbestos packing for the glass to bed upon. This reduces the danger of breakage which would otherwise follow after any extraordinary vibration from storm or shock, this danger most generally existing in buildings of steel or iron construction.

There are two varieties of Heywood's patent system. In one, called *ordinary* (No. 1, fig. 1042), the lead strip that receives the glass is mounted on a galvanized-steel bar, which can be obtained of varying depths according to the distance the bar is required to span. It will be observed that this varies from the Simplex system in the following important particulars, viz.,

in the condensation grooves and asbestos packing, already pointed out, and in the T bar being set reversely. It will also be seen that, whilst in the Simplex system the water can easily get between the lead and iron, causing corrosion of the latter, this is impossible in the Heywood system, since the lead is so arranged that the iron is protected, and only exposed where any condensation would fall away immediately.

The lead-clothed bar is a galvanized T bar entirely enclosed in lead (No. 2, fig, 1042), the ends being soldered up; thus the bar is hermetically sealed, and any possibility of decomposition from rust is prevented. The glass rests on an asbestos cushion, as in the ordinary section, which excludes dust and weather as well as preventing fracture from vibration. Actual contact with the glass occurs only on the narrow cushion of asbestos and on the outside rim of the upper leaf, leaving a clear channel within to carry away any moisture that may happen to pass the narrow rim or be condensed on the iron. There is no attempt in this method to join the glass with the bar, but merely to effect a waterproof joint by means of overlapping, whereas glazing with putty, lead glazing, and lastly the Simplex glazing, are all methods of uniting metal or wood, as the case may be, with the glass by means of an adhesive paint or putty.

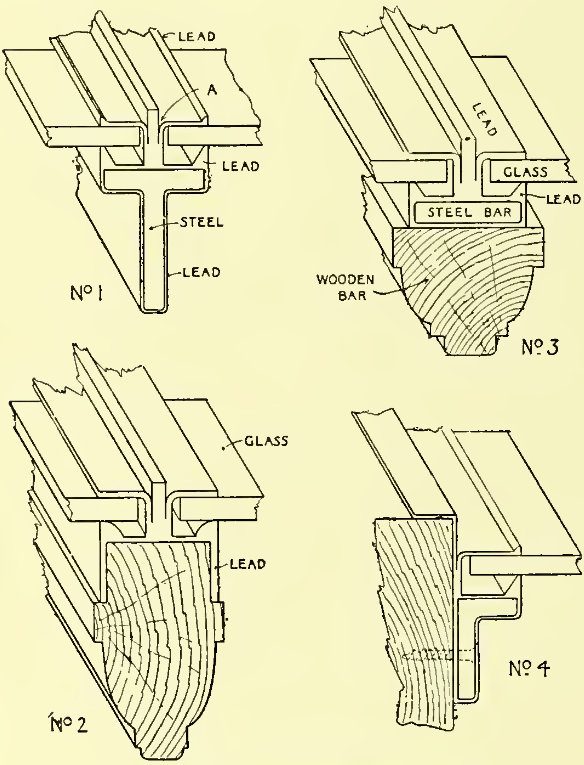


Fig. 1043.—The British Challenge Glazing

We will now review, as inclusively as possible, the various forms resulting from the adoption of the lap-and-channel principle. It is obvious that as these methods depend entirely upon the easy and rapid gravitation of water for their success, the pitch of the roof should not be less than will assure the water flowing away before it fills the channels. In all cases the pitch of the roof should be at least 30°, for otherwise the condensation will drip from the glass instead of running down to the plate where provision is made for its escape to the outside.

The British Challenge glazing (fig. 1043) is another example of a lead-clothed steel bar with wings folded over to keep the glass in position, as

shown in No. 1. The glass is arranged to rest on a wedge-shaped piece of lead which forms the outer edge of the enclosed channel. The deep cut on either side at A serves to distribute the strain upon the lead, when it is turned back and dressed down again in the event of breakage. Earlier systems allowed the glass to rest upon the flat flange of T iron, but this arrangement offers more resistance to the glass and so increases the liability of breakage. The British Challenge glazing can also be procured for fixing to wooden bars (No. 2), and for the

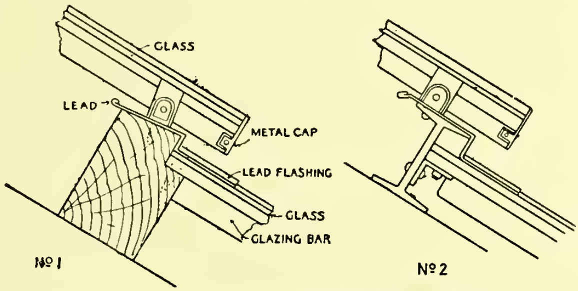


Fig. 1044.—Overlaps in the British Challenge Glazing

same purpose can be procured with steel cores (No. 3). Special sections are required for end bars (No. 4). These are L-shaped, with the outer wing of lead made a trifle wider in order to lap over the woodwork, to which it is secured with copper nails, or in the case of abutments to brickwork to form the soaker over which the stepped flashing can be fixed. The bars are made for bearings from 4 ft. 6 in. to 12 ft., and it should be noted that glass must not be lapped with this section. If the length to be covered is beyond the maximum span the roof should be broken by a purlin, as shown in No. 1, fig. 1044. In the case of steel construction the glazing bar of the upper part of the roof should be bolted to the upper side of the steel purlin, as shown in No. 2, and a lead apron should be cut sufficiently wide to project beyond the purlin and be doubled over to form a lip for

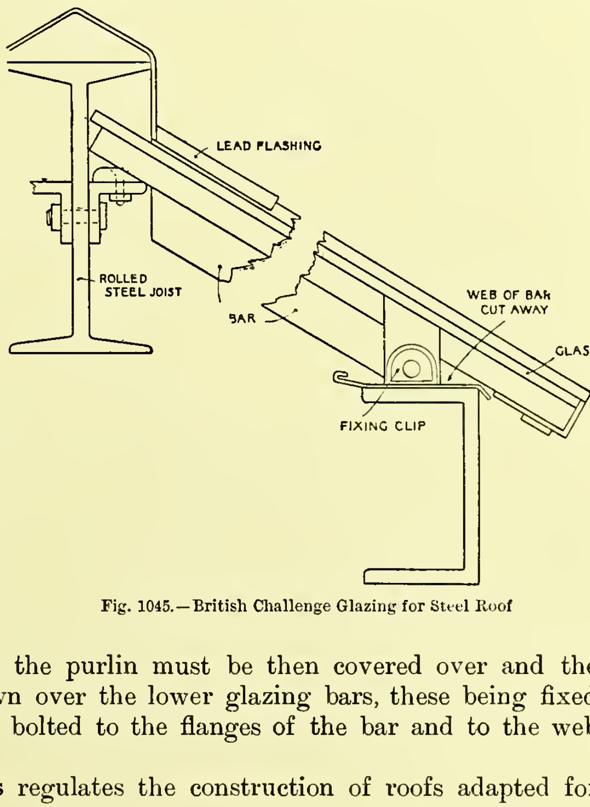


Fig. 1045.—British Challenge Glazing for Steel Roof

condensation; the top of the purlin must be then covered over and the lead must be dressed down over the lower glazing bars, these being fixed by means of angle pieces bolted to the flanges of the bar and to the web of the purlin.

As **the length of glass** regulates the construction of roofs adapted for

this kind of glazing, it will be well to give approximately the lengths procurable in the different kinds of glass. Quarter-inch wire wove, Hartley's, cathedral, and figured rolled glass can be obtained up to 10 ft. in length; English sheet glass up to 6 ft. or 6 ft. 6 in.; foreign sheet glass up to 4 ft. 6 in.; 26-oz. fluted glass up to 5 ft.; 32-oz. fluted glass up to 4 ft. 6 in.; plate glass up to 12 ft.

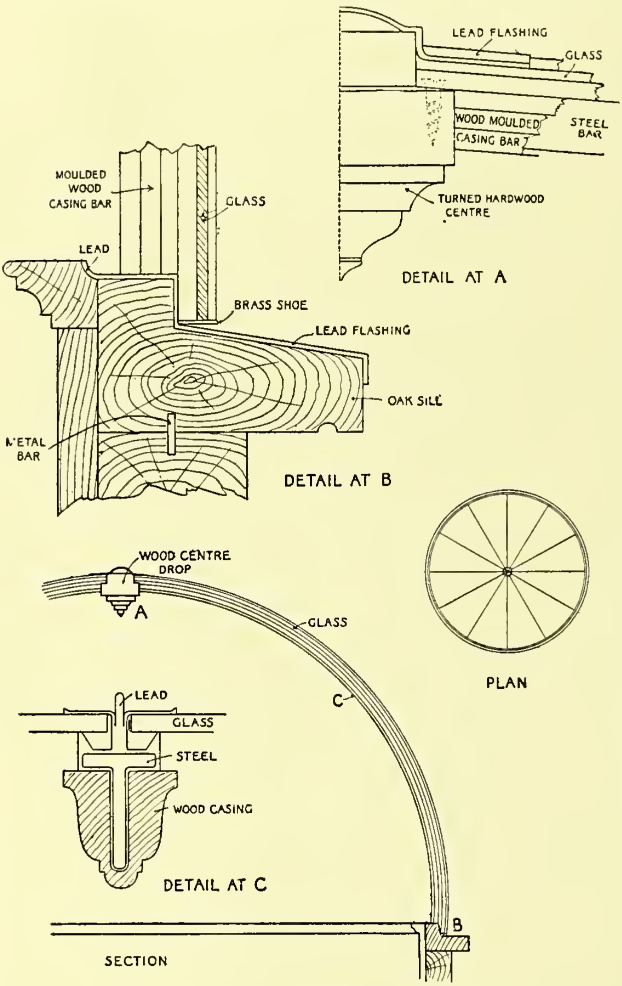


Fig. 1046.—Dome in British Challenge Glazing

The bars should be ordered to the exact lengths required, and particulars given as to whether they are needed for steel or wood construction, because in the case of the former there is a special bar with the web cut away and the flange bent over at the top to bolt it to the steel ridge, and cut away on the splay at the bottom end to rest on the steel curb (fig. 1045). For the projecting ends at the eaves the Challenge glazing bar is fitted with a brass shoe having small perforations to allow for the escape of condensed moisture from the inner channels.

This section can also be obtained for **curved or domed glazing.** In the latter case the sections can either be housed into a hard wood centre piece covered with lead, or bolted together with small angle plates to the web of the bars. Domes of over 10 ft. diameter are not practicable in this method without special construction, but the company offers a good suggestion for this class of work (fig. 1046).

The Challenge method of fixing the bars in a vertical position is worth consideration (fig. 1047), as it is sound and durable. $1\frac{1}{2}$-in. angle-iron bars are fixed at the head and sill, and in the case of a transome a 2-in **T** is employed, partly covered with lead as shown. The lead forms a seating for the

vertical bars and enables them to be screwed firmly to the angle and T bars without fear of fracture, thus protecting the steel from moisture and at the same time serving the main purpose of keeping out the wet at the junction of the bars with the head, sill, and transome. In the case of wood heads and sills the vertical bars would be fixed in the ordinary way with brackets supplied for the purpose. The best effect is obtained by covering the top rail entirely with lead on the upper side, bringing it well down over the glass in front, then dressing it neatly to the bar section. The lead should be put on first, and the bars fixed afterwards, the brackets being screwed on to the lead with thick red-lead paint bedded in between, only the final dressing and trimming of lead to be left after fixing the bars.

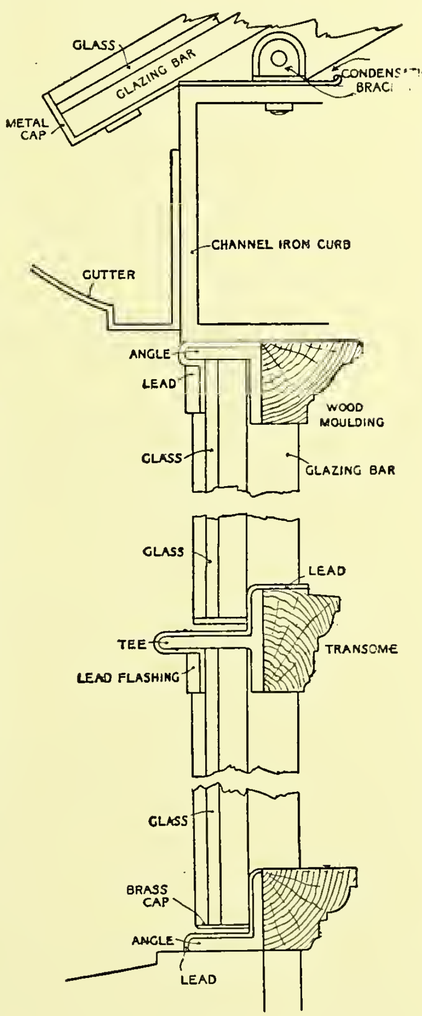


Fig. 1047.—Vertical Glazing: British Challenge System

Ventilation in this, as in most systems of glazing, should occur at the top of the roof, so that the vents can be properly flashed. Challenge ventilators are made of T iron arranged to lap the central projecting piece of the bar (No. 1, fig. 1048), and to form the rebate on the upper side for glass. On the vacant rebate of the glazing bar an angle iron is fixed and the lead wing trimmed off at the apex (see fig. 1048). The angle iron at the bottom is fixed reversely with another angle iron attached to the ventilator and overlapping with the glass, the bars being carried well over to prevent the possibility of wet being driven back by the force of the wind (No. 2, fig. 1048). It is winged from the top, care being taken to allow the lead flashing plenty of play. The most satisfactory job for hinged skylights is made by a double flashing which leaves the outer apron quite free, whilst the under lead is fixed to the ridge or wall plate as the case may be and dressed over the skylight. Much of course depends upon the position of the butt hinges and the form of skylight, and also upon the local conditions. It is one of the points that need careful watching and arrangement to ensure that the constant working of the ventilator does not cause the lead to split, and as a certain amount of friction is unavoid-

able the second lap of sheet lead should be so arranged as to retain its original position whether the ventilator is open or shut.

Pennycook's system likewise has a lead-sheathed steel bar with double

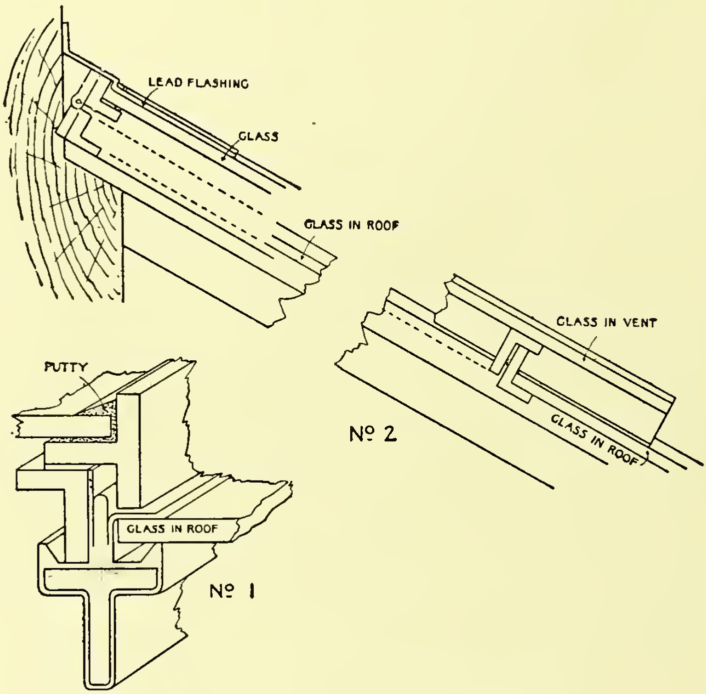


Fig. 1048.—Ventilator in British Challenge Glazing

grooves on either side (fig. 1049), the sections being capable of spanning from 6 to 13 ft. To reap the fullest advantage of the groove provided for condensation, the convex side of the glass should be uppermost. In most kinds of glass a slight curve is apparent, and if these directions for glazing are carefully followed the condensation water will drain into the grooves without further trouble. In the majority of special glazing systems this is the better course to follow, although in ordinary putty glazing the reverse is observed, the object being in this latter case to drain the water from the bars and encourage it to run down the middle of the panes of glass. In a long roof a drip should be formed at least every 10 ft. This should leave about 4 in. from face to face of the upper and lower sheets of glass, and can be formed by slightly tilting the L, T, or H purlins, so that it will not be necessary to pack out from the principal rafter (fig. 1050). The lead flashing enables the condensed moisture to escape without draught and also effectually prevents any driving back.

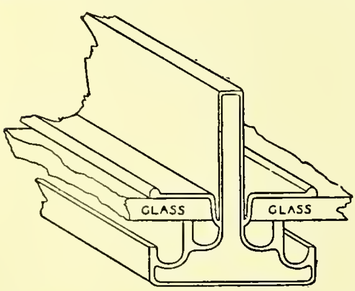


Fig. 1049.—Pennycook's Glazing System

Messrs. Mellowes & Co.'s Eclipse glazing, in addition to the double channel, has wings or webs as an extra guard against wind and weather (fig. 1051). This system was used when it was found necessary to

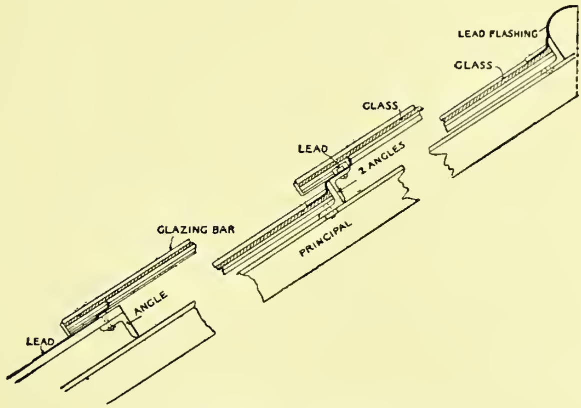


Fig. 1050.—Drips or Overlaps in Long Roof

reglaze part of the Crystal Palace. The Eclipse cover for wood bars (No. 2) has only one channel at the bottom, otherwise it is practically the same as lead-cased steel bars. Sheathed steel bars are fitted with copper caps at the ends, and take the same span as the majority of patent

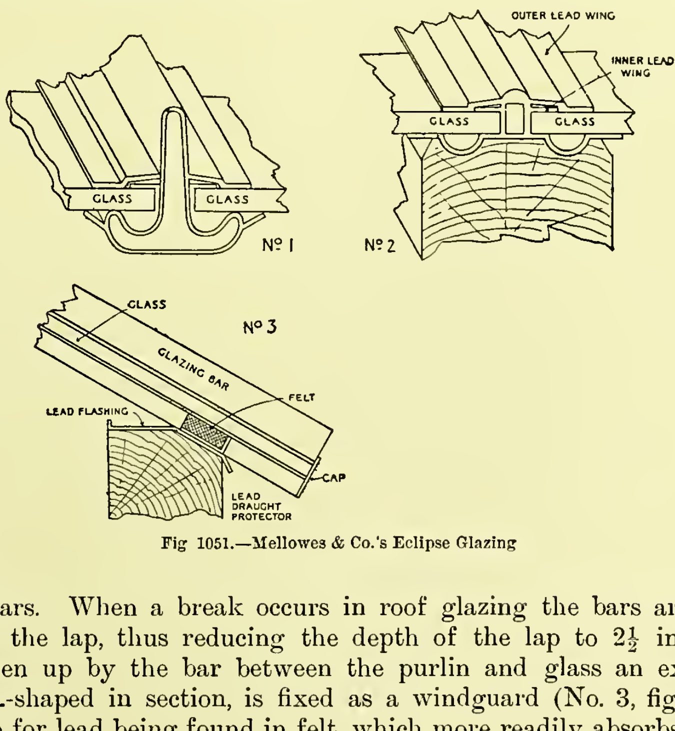


Fig 1051.—Mellowes & Co.'s Eclipse Glazing

glazing bars. When a break occurs in roof glazing the bars are splayed off under the lap, thus reducing the depth of the lap to $2\frac{1}{2}$ in. In the space taken up by the bar between the purlin and glass an extra piece of lead, L-shaped in section, is fixed as a windguard (No. 3, fig. 1051); a substitute for lead being found in felt, which more readily absorbs moisture

and prevents draughts, but is less durable. Sometimes both lead and felt are used.

The British Luxfer Prism Syndicate makes a lead-cased section with

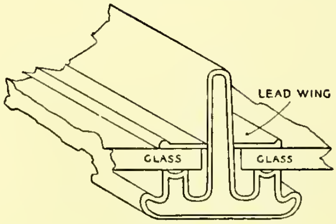


Fig. 1052.—British Luxfer Prism Syndicate's Glazing System

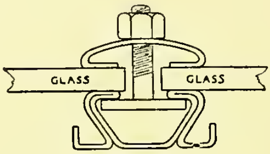


Fig. 1053.—Rendle's Invincible Glazing

double grooves on either side and a hollow bed for the glass to rest upon (fig. 1052). This section is calculated to carry 8 ft. between the purlins, and the break at the purlins would be arranged as in the previous sections.

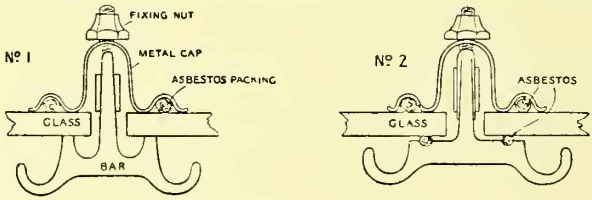


Fig. 1054.—Helliwell's Perfection Glazing

The same makers have a steel bar with a copper cap (fig. 1055), but as the glass has no bed except on iron other sections will be found more suitable for steel-constructed buildings. It is used for fixing their metal-glazed prisms and serves that special purpose admirably.

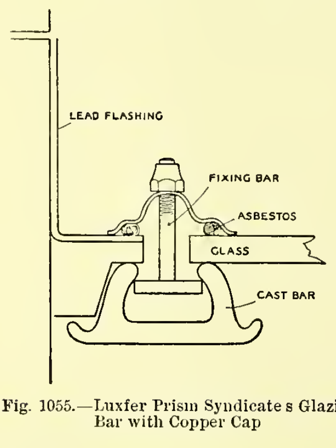


Fig. 1055.—Luxfer Prism Syndicate s Glazing Bar with Copper Cap

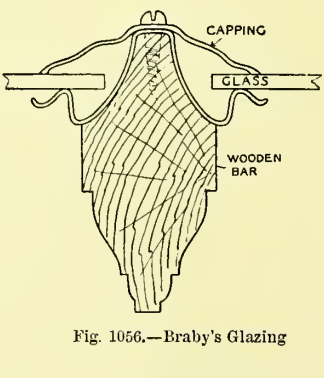


Fig. 1056.—Braby's Glazing

Of the other systems of dry glazing with zinc and copper the following are worth noting.

Rendle's Invincible (fig. 1053) has the section arranged obliquely, so

that it may give with any extraordinary pressure and prevent fracture of glass. In fixing this care must be taken not to screw the nuts (which fix the caps and glass) too tightly. This section is supplied both for wood and iron bars, but may be employed alone for short lengths up to 4 ft.

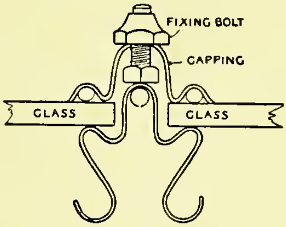


Fig. 1057.—Helliwell's Glazing with Zinc Cap

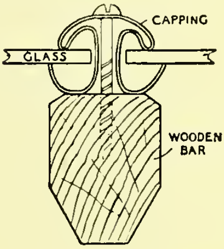


Fig. 1058.—Clark's Glazing

Helliwell's Perfection glazing has bars of iron with a lead or zinc cap fixed by a patent hard-metal clip screwed down with a brass bolt and nut (fig. 1054). The glass beds directly upon the iron, and in some cases this may be a source of danger; it is, however, obviated in the **G** section bar (No. 2, fig. 1054), which has asbestos seating for the glass both above and

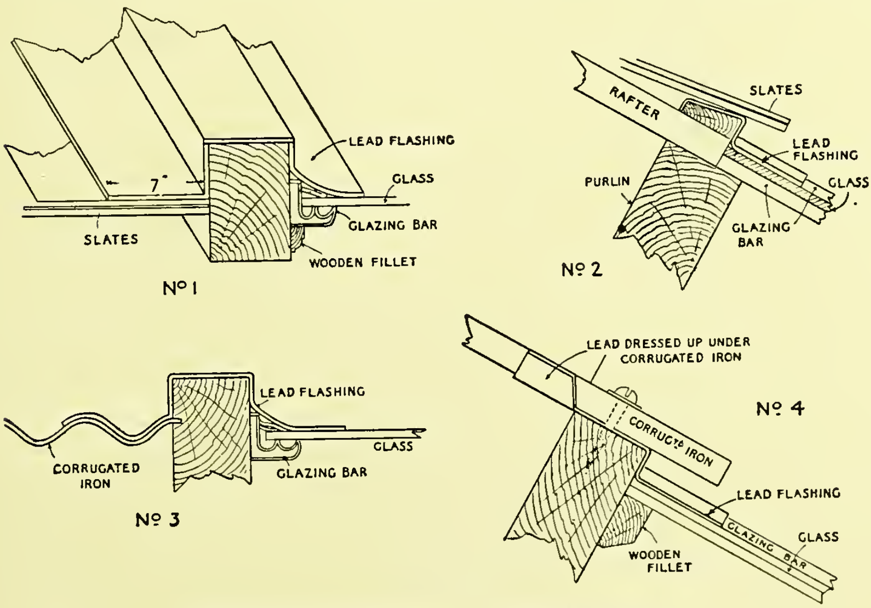


Fig. 1059.—Special Glazing on Slate and Corrugated-iron Roofs

below, thus preventing the actual contact of the glass and iron, and in this section we find the ends finished with brass stops.

In addition to these there are **zinc sections** made for light roof glazing. We give three examples, which speak for themselves:—Messrs. Braby's (fig. 1056), Messrs. Helliwell & Co.'s (fig. 1057), and Messrs. Clark's of Reading (fig. 1058).

In conclusion we give one or two sections showing patent glazing joined on to slates and corrugated iron (fig. 1059). No. 1 is a section through the side of a toplight in a slated roof, and shows a raised wooden frame over which the lead flashing is laid; No. 2 is a section through the top of a similar skylight, the lead flashing in this case being carried over the tilting fillet under the slates. Nos. 3 and 4 are sections through the side and top of a skylight in a corrugated-iron roof.

No outside painting is necessary in these systems, and only in a few cases is it necessary on the inside. The difficulty of access to roofs makes the painting of large ones a very heavy item, and it will be easily understood that these ingenious contrivances for glazing supply a real necessity and will always be in demand in some shape or form.

Section XV.—SPECIFICATIONS, QUANTITIES AND ESTIMATES

BY

W. E. DAVIS

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SECTION XV.

SPECIFICATIONS, QUANTITIES, AND ESTIMATES

CHAPTER I

MEASUREMENT OF EXTERNAL PLUMBERS' WORK

There are few trades in which the surveyor has to use his discretion more than in the one under consideration. From the very nature of the work, it is impossible to show on the drawings all the details. In addition to this there are numerous "allowances" that have to be made for passings, rolls, drips, &c. Frequently the information given on the drawings and in the specification is somewhat scanty; the surveyor therefore must be in a position to supplement this according to the generally accepted rules of the trade.

A general rule to be safely followed is to consider 10 ft. as the maximum length of the sheets to be used in flats, gutters, or flashings, or in fact in any work, and in the case of flats to allow for rolls being at a maximum spacing of 2 ft. 6 in. It will therefore be necessary to take drips in flats and gutters, and laps or passings in flashings, &c., wherever this length is exceeded.

In this connection, as in most other subjects, a practical demonstration is worth a great deal of theory. We therefore give in Plate XLIV a series of drawings showing most of the forms of leadwork on an ordinary roof, and an average specification is given below, followed by examples of "taking-off", "abstracting", and "billing". The student, by carefully following these, will be in a position to deal with any ordinary measurement of "external plumbers' work". The measurement of more elaborate work is only an extension of the general principles herein set forth.

In the absence of any special notes in the specification, the following allowances are usually considered fair:—Rolls on flats, in addition to the full measurement of flat, 9 in. for each 2-in. roll and 7 in. for each $1\frac{1}{2}$ in.; ridge and hip rolls, 1 ft. 6 in. girth; cover flashings, 6 in.; stepped flashings, 8 in. wide; apron flashings, 1 ft. girth; turn up of gutters and flats,

6 in. against walls and other vertical faces, and 9 in. up slopes of roofs; passings and angles in flashings, coverings to hip and ridge rolls, &c., 6 in. each, with a similar allowance at each end.

SPECIFICATION

Generally. All lead to be best milled and of the full weights specified, and to be well and evenly dressed without injury to the surface.

No solder to be used except where absolutely unavoidable.

Gutters and Flats. Lay the flat and gutters (except secret gutters and those behind chimneys) with 7-lb. lead laid to falls of 1½ in. in 10 ft., with 2½-in. drips, and neatly dressed over rolls and to roof slopes, &c. Form bossed (or soldered) cesspools at ends of valley gutters lined with similar lead, and carry from each a 3-in. drawn-lead pipe of 8-lb. lead into rainwater head.

The gutters behind chimneys to be laid with 6-lb. lead.

Dormer. The top of dormer to be covered with 6-lb. lead laid to proper falls, neatly dressed over rolls, and with 5-lb. lead copper-nailed strips at sides and along front edge. The cheeks of dormer to be covered with 5-lb. lead secured with necessary screws and washers and soldered dots, and to have narrow strips as above closely copper-nailed to the vertical edges, and the top edges fixed with open copper nailing.

Valleys. The valleys to be laid with 6-lb. lead 18 in. wide, welted, and open copper-nailed on both edges.

Hips and Ridges. The hip and ridge rolls, where shown, to be covered with 5-lb. lead.

The hip A to have 4-lb. lead soakers 9 in. wide, worked in with the slates.

The hips B to have 4-lb. lead secret lining 9 in. wide, with welt on both edges.

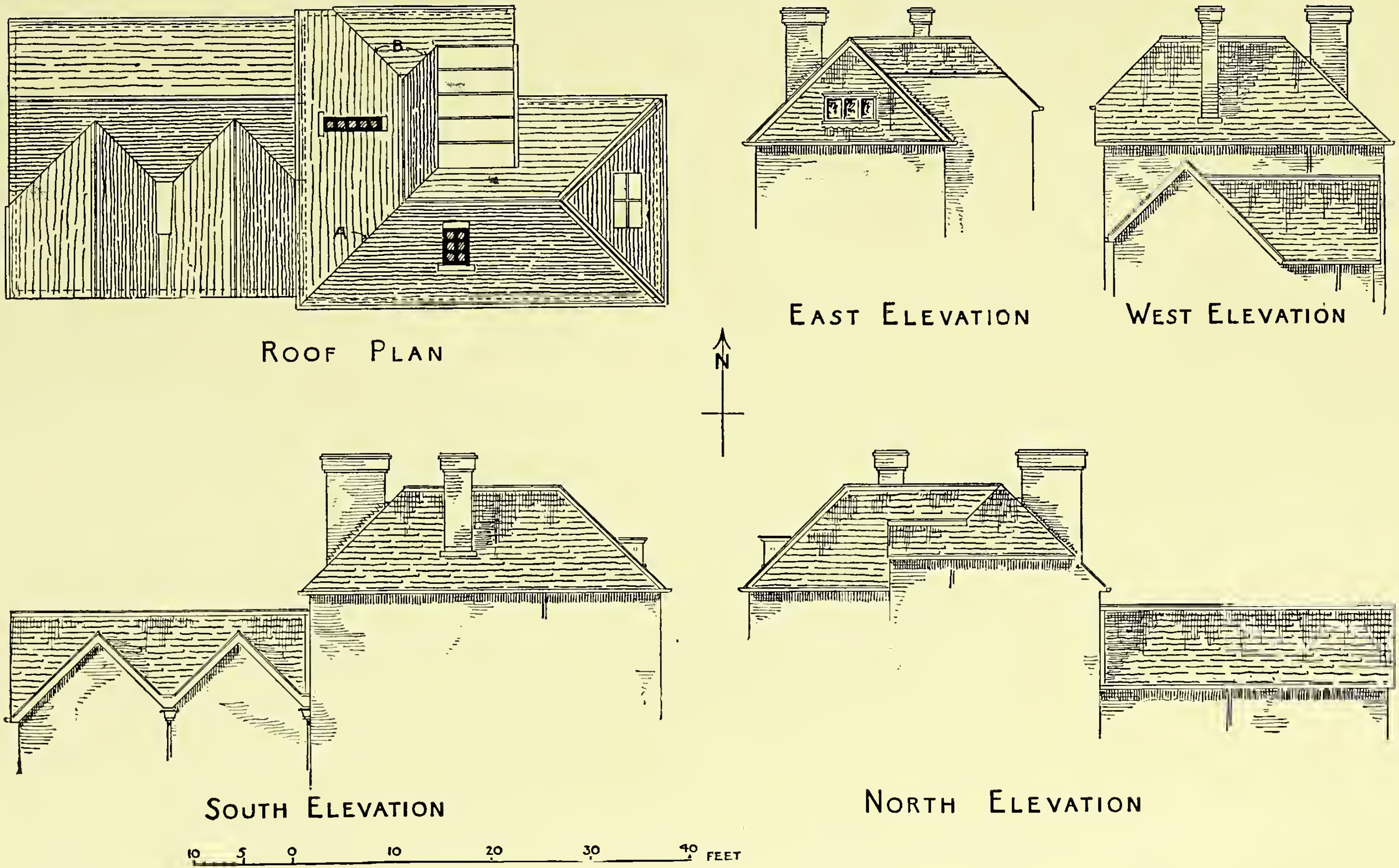
Flashings, &c. All flashings to be of 5-lb. lead. Cover flashings, 6 in. wide; stepped do., 8 in. wide; apron flashings, 1 ft. wide; stepped do., 1 ft. 2 in. wide. That to front of dormer to be turned up behind sill and close copper-nailed, and the lower edge to be escalloped to detail.

The sides of chimneys to have 5-lb. lead secret gutters 1 ft. wide.

The slopes of lower roof against brickwork and to sides of dormer to have 4-lb. lead soakers 10 in. wide, worked in with the slates, with cover flashing as above.

The slopes of upper roof against brickwork (except to chimneys) to have apron flashings as above.

PLATE XLIV



PLAN AND ELEVATION OF HOUSE SHOWING EXTERNAL PLUMBING

TAKING-OFF

			FLAT	
				Length of flat, 12′ 6″ *Up slope,* 0′ 9″ *Rolls,* 5/9″ = 3′ 9″ 17′ 0″ *Width of flat,* 8′ 0″ *Up slope,* 0′ 9″ *Into gutter,* 0′ 3″ 9′ 0″
	17·0 9·0	153·0	7-lb. lead flat.	
	5/		Bossed ends to rolls.	
	5/		Do. against slope of roof.	
			GUTTERS	
				Length of gutter, 12′ 0″ *Up slope,* 0′ 9″ *Drip,* 0′ 8″ *Roll at front,* 0′ 9″ 14′ 2″ Between slopes *Width at top,* 1′ 7″ *Do. bottom,* 0′ 9″ 2′ 4″ *Average,* 1′ 2″ *Up slopes* 2/9″ = 1′ 6″ 2′ 8″
	14·2 2·8	37·9	7-lb. lead gutter.	
2/4/	0·9 0·6	3·0	Add	*Cesspool.*
		40·9		
	2/1/	= 2	Extra labour and solder to cesspool.	
	2/1/	= 2	3-in. lead outlet pipe 1 ft. 6 in. long = 8-lb. lead, one end tafted and soldered to lead cesspool, the other dressed into rainwater head. and Copper wire domical grating over outlet.	
				Against wall *Width at top,* 1′ 3″ *Do. bottom,* 0′ 9″ 2′ 0″
	14·2 2·3	31·11	7-lb. lead gutter.	*Average,* 1′ 0″ *Up slope,* 0′ 9″ *Up wall,* 0′ 6″ 2′ 3″
			NOTE.—Cesspool, &c., twiced with previous items.	
				Length of flashing, 12′ 0″ *Passing,* 0′ 6″ *Ends,* 2/6″ 1′ 0″ 13′ 6″
	13·6 0·6	6·9	5-lb. lead cover flashing.	
	13·0		Lead wedging. NOTE.—The "passing" is not added in this item.	

			VALLEYS	
				Long valley lower roof *Length of valley,* 14′ 6″ *Passing,* 0′ 6″ *Ends,* 2/6″ 1′ 0″ 16′ 0″
	16·0 1·6	24·0	6-lb. lead valley including welted edges.	
2/	14·6	29·0	Open copper nailing.	
				Three short valleys lower roof *Length of valley,* 11′ 0″ *Passing,* 0′ 6″ *Ends,* 2/6″ = 1′ 0″ 12′ 6″
3/	12·6 1·6	56·3	6-lb. lead valleys as before.	
3/2/	11·0	66·0	Open copper nailing.	
				Valley upper roof *Length of valley,* 5′ 6″ *Ends,* 2/6″ 1′ 0″ 6′ 6″
	6·6 1·6	9·9	6-lb. lead valleys as before.	
2/	5·6	11·0	Open copper nailing.	
			RIDGES AND HIPS	
				Lower roof *Length of ridge.* 30′ 0″ *Do.* 18′ 0″ *Do.* 18′ 0″ 66′ 0″ *Passings,* 1·1·2/6″ = 2′ 0″ *Ends,* 3/2/6″ 3′ 0″ 71′ 0″
	71·0 1·6	106.6	5-lb. lead covering to ridge roll.	
	3/		Bossed ends to rolls.	
	1/		Do. against vertical face.	
	2/		Do. against sloping face.	Upper roof *Length of ridge,* 13′ 0″ *Do.* 16′ 0″ 29′ 0″ *Passings,* 2/6″ = 1′ 0″ *Ends,* 2/6″ = 1′ 0″ *Angle,* 0′ 6″ 31′ 6″
	31·6 1·6	47·3	5-lb. lead covering to ridge roll.	
	1/		Bossed returned end.	
	1/		Bossing at mitre.	

	1/		Bossing at intersection of ridge and two hip rolls.	*Length of hip,* 18′ 0″ *Passings,* 0′ 6″ *Ends,* 2/6″ = 1′ 0″ 19′ 6″
2/	19·6 1·6	58·6	5-lb. lead covering to hip roll.	
	2/		Bossing at feet of hip rolls.	Hip A
			NOTE.—The length of hip is 18 ft., and allowing one soaker to each course of slating, the slates being of "countess" size laid to a gauge of 8 in., the number of soakers on this length will be 27, therefore—	
27/	0·9 1·0	20·3	4-lb. lead soakers (fixing by slater).	Hips B *Length of hip,* 12′ 0″ *Do.* 5′ 6″ 17′ 6″ *Passing,* 0′ 6″ *Ends,* 2/2/6″ = 2′ 0″ 20′ 0″
	20·0 0·9	15·0	4-lb. lead hip including welted edges.	

WORK AROUND CHIMNEYS

2/	15·0 1·0	30·0	5-lb. lead in secret gutters.	Secret gutters to chimneys *Length on slope,* 8′ 0″ *Do.* 5′ 0″ 13′ 0″ *Ends,* 2/2/6″ = 2′ 0″ 15′ 0″
2/	15·0	30·0	Lead wedging to stepped flashing.	Aprons to chimneys *Length,* 1′ 6″ *Do.* 2′ 8″ 4′ 2″ *Ends,* 2/2/6″ = 2′ 0″ 6′ 2″
	6·2 1·0	6·2	5-lb. lead apron.	
	6·2		Lead wedging.	
			Width, 6″ Turn-up on roof, 9″ Do. chimney, 6″ 1′ 9″	Gutters behind chimneys Length, 1′ 6″ Do. 2′ 8″ 4′ 2″ Ends, 2/2/6″ = 2′ 0″ 6′ 2″
	6·2 1·9	10·10	6-lb. lead gutters.	
	6·2 0·6	3·1	5-lb. flashing.	
	6·2		Lead wedging.	

			WORK TO SLOPES NEXT BRICKWORK	
2/18/	0·10 1·0	30·0	4-lb. lead soakers.	Lower roof *Length of slope*, 12′ 0″ See "soakers to hips" for arriving at number *Length*, 12′ 0″ *Passing*, 0′ 6″ *Ends*, 2/6″ = 1′ 0″ 13′ 6″
2/	13·6 0·8	18·0	5-lb. stepped flashing.	
2/	13·0	26·0	Lead wedging to stepped flashing.	
	12·3 1·2	14·4	5-lb. stepped flashing.	Upper roof *Length of slope*, 10′ 9″ *Passing*, 0′ 6″ *Ends*, 2/6″ = 1′ 0″ 12′ 3″
	11·9		Lead wedging to do.	
			DORMER	
	6·3 4·11	30·9	6-lb. lead covering to dormer top, including rolls and welted edges.	Top (1½″ rolls) *Width*, 3′ 6″ *Welt*, 0′ 1″ *Up roof*, 0′ 9″ *Roll*, 0′ 7″ 4′ 11″ *Length*, 5′ 6″ *Welts*, 2/1″ 0′ 2″ *Roll*, 0′ 7″ 6′ 3″
	12·6		Strip of 5-lb. lead 2 in. wide, close copper nailed one edge.	5′ 6″ 2/3′ 6″ = 7′ 0″ 12′ 6″
	3/		Bossed ends to rolls.	
	1/		Do. against slope of roof.	
	1/		Bossing at 4-way intersection.	
2/½/	3·6 3·6	12·3	5-lb. lead to dormer cheeks.	Cheeks
2/	3·6	7·0	Strip of 5-lb. lead 3 in. wide, close copper nailed and welted (*to vertical front edges*).	
	2/		Solder dots and brass screws and washers.	
2/	3·6	7·0	Open copper nailing.	
2/8/	0·10 1·0	13·4	4-lb. lead soakers.	Soakers *Length of slope*, 5′ 0″ = 8 soakers
	6·6 1·0	6·6	5-lb. lead apron.	Apron *Length of sill*, 5′ 6″ *Ends*, 2/6″ = 1′ 0″ 6′ 6″
	5·6		Close copper nailing to oak.	
	6·6		Cutting escalloped edge to 5-lb. lead apron to detail.	

Super.

7-lb. lead flats and gutters.

153·0
40·9
31·11
———
225·8
× 7
———
1580 lb.
65 „
113 „
———
1758 lb.

cwt. 15·2·22

6 lb. do.
———
10·10
× 6
———
65 lb.

5-lb. lead flashings.

6·9
6·2
3·1
6·6
———
22·6
× 5
———
113 lb.

5-lb. lead stepped do.
———
18·0
14·4
———
32·4
× 5
———
162 lb.

cwt. 1·1·22.

6-lb. lead valleys, including welted edges.

24·0
56·3
9·9
———
90·0
× 6
———
540 lb.
60 „
———
600 lb.

cwt. 5·1·12.

4-lb. lead hip including do.
———
15·0
× 4
———
60 lb.

5-lb. lead covering to ridge and hip rolls.

106·6
47·3
58·6
———
212·3
× 5
———
1061 lb.

cwt. 9.1.25.

5-lb. lead in secret gutters.
———
30·0
× 5
———
150 lb.

cwt. 1·1·10.

4-lb lead soakers (fixing by slater).

20·3
30·0
13·4
———
63·7
× 4
———
254 lb.

cwt. 2·1·2.

6-lb. lead covering to dormer top, including rolls and welted edges.

30·9
× 6
———
185 lb.

cwt. 1·2·17.

5-lb. lead to dormer cheeks.
———
12·3
× 5
———
61 lb.

cwt. 0·2·5.

Run.

Cutting escalloped edge to 5-lb. lead apron to detail.

6·6

Lead wedging to flashings.

13·0
6·2
6·2
———
25·4

Do. to stepped flashings.
———
30·0
26·0
11·9
———
67·9

Open copper nailing.

29·0
66·0
11·0
7·0
———
113·0

Close do. to oak.
———
5·6

Strip of 5-lb. lead 2 in. wide, close copper nailed one edge.

12·6

Do. 3 in. wide do. and welted.
———
7·0

Nos.

Bossed ends to rolls.

5 Do. against slope of roof.
3
3
———
11

5 Do. against vertical face.
2
1
———
8

1 Do. at 4 way intersection.
———
1

Bossed returned end to ridge roll.

1 Do. at mitre.

1 Do. at intersection of ridge and 2 hip rolls.
———
1

Bossing at feet of hip rolls.

2 Solder dots and brass screws.
———
2

Extra labour and solder to cesspool.

2 Copper wire domical grating over outlet.
———
2

3-in. lead outlet pipe 1 ft. 6 in. long = 8-lb. lead, one end tafted and soldered to lead cesspool, the other dressed into rainwater head.
———
2

BILLING

Cwt	qr.	lb.				£	s.	d.
				All lead to be best milled and of the full weights specified, and to be well and evenly dressed without injury to the surface. No solder to be used except where absolutely unavoidable.				
15	2	22		Milled lead and labour in flats, gutters, and flashings	30/	23	10	11
1	1	22		Do. in stepped flashings	30/6	2	4	1
5	1	12		Do. in valleys and hips, including welted edges ...	30/6	8	3	5
1	1	10		Do. in secret gutters	31/	2	1	6
9	1	25		Do. in covering to hip and ridge rolls	30/6	14	9	0
0	2	5		Do. in covering to cheeks of dormers	30/6	0	16	7
1	2	17		Do. in covering to tops of dormers, including rolls and welted edges	30/9	2	10	9
2	1	2		Do. in soakers (fixing by slater)	26/	2	19	0
	Ft.							
	7		run	Cutting escalloped edge to 5 lb. apron to detail ...	/8	0	4	8
	25		"	Lead wedging to flashings	/1¾	0	3	8
	68		"	Do. to stepped do.	/2	0	11	4
	113		"	Open copper nailing	/2	0	18	10
	6		"	Close do. to oak	/3	0	1	6
	13		"	Strip of 5-lb. lead 2 in. wide, close copper nailed one edge	/6½	0	7	1
	7		"	Do. 3 in. wide do. and welted	/9½	0	5	7
		No.	11	Labour to bossed ends to rolls	/6	0	5	6
			1	Do. to do. against vertical face	/6	0	0	6
			8	Do. to do. against slope of roof	/6½	0	4	4
			1	Do. to bossing at 4-way intersection	1/10	0	1	10
			2	Do. to bossed ends to hip rolls	/6½	0	1	1
			1	Do. to bossed returned end to ridge roll	/10	0	0	10
			1	Do. to bossing at mitre in do.	/8	0	0	8
			1	Do. to bossing at intersection of ridge and two hip rolls	1/6	0	1	6
			2	Solder dots and brass screws	1/	0	2	0
			2	Extra labour and solder to cesspool	3/6	0	7	0
			2	Copper wire domical gratings over outlets in do. ...	2/	0	4	0
			2	3 in. diameter lead outlet pipes 1 ft. 6 in. long, equal to 8-lb. lead, one end tafted and soldered to lead cesspool, the other dressed into rainwater head ...	8/4	0	16	8
					£	61	13	10

Note.—The price of lead being subject to great fluctuation, these prices must be taken as approximate only for good class work. They are under ordinary conditions remunerative when the cost of the lead does not exceed £22, 15*s.* per ton.

CHAPTER II

MEASUREMENT OF INTERNAL PLUMBERS' WORK

The first paragraph of Chapter I applies with equal force to this chapter as to the former one, the surveyor having to settle in his mind the run of the pipes which will, in all probability, be adopted by the plumber in executing the work.

In order to give a practical demonstration of the method of measuring

and preparing a Bill of Quantities, we have taken as an example the Drawings (figs. 1060 and 1061), Specification, Dimensions, Abstract and Bill of Work actually carried out for a house, and have amplified the

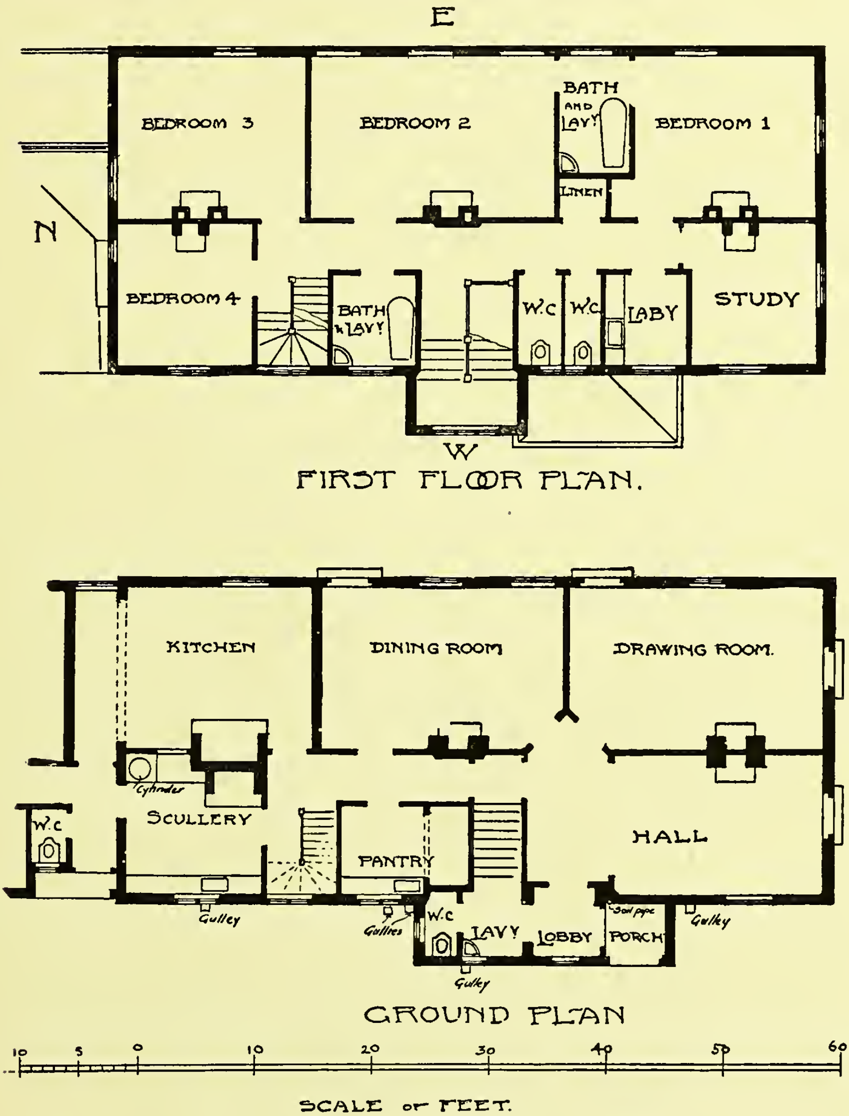
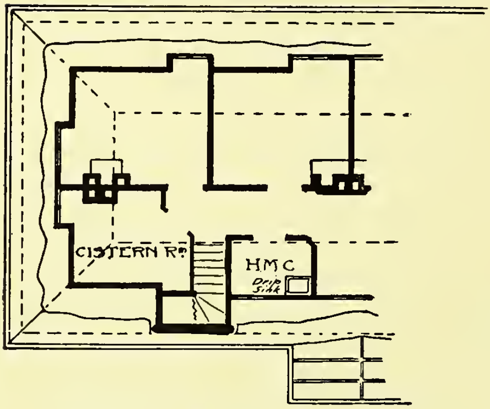


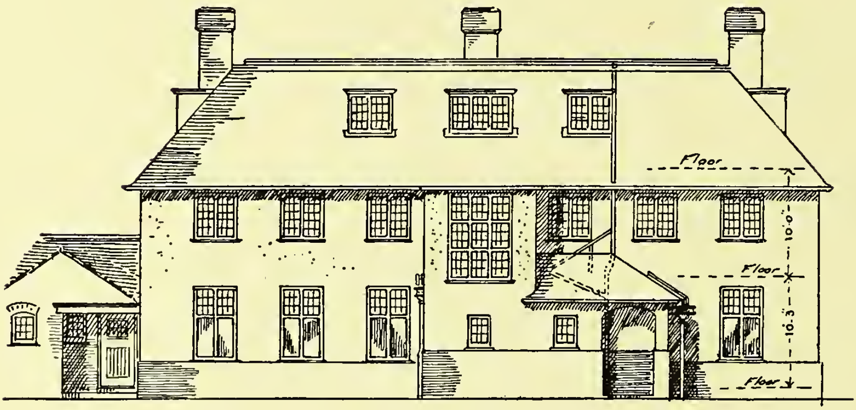
Fig. 1060.—Ground-floor and First-floor Plans of House

references in the Dimensions where necessary, to enable the reader more easily to trace the measurements from the Drawings.

In "taking-off" the items are taken generally in the order of the Specification.



SECOND FLOOR PLAN.



WEST ELEVATION.

Fig. 1061.--Elevation and Part of Second-floor Plan of House

SPECIFICATION

(See figs. 1060 and 1061.)

Generally. All lead to be best milled and of the full weights specified.

Lead pipes to be best drawn, all dimensions given being internal, and to be laid complete with all necessary wiped solder joints, holdfasts, brass unions, lead tacks, &c., and so as to empty themselves.

All cocks to be best full-way high-pressure screw-down in gun metal, from an approved maker, with screwed bosses.

All iron pipes to be best galvanized wrought-iron steam tubing fitted with bends, junctions, short pieces, and all necessary connectors, galvanized holdfasts, &c.

Cisterns. Provide and fix in cistern room two wrought-iron galvanized and riveted cisterns of $\frac{1}{8}$-in. plate to hold 150 gallons each, connected near the bottom with $1\frac{1}{4}$-in. iron pipe and flynuts; fix in side of one cistern $\frac{3}{4}$-in. full-way equilibrium ball valve with large copper ball, screw ferrule, flynut, and union, and connect supply pipe to same; fix $1\frac{1}{2}$-in. lead overflow pipe 14 lb. per yard, connected to cistern with brass boiler-screw union, flynut, and washer, and made to discharge into lead safe over the outlet from same.

Under cisterns fix 5-lb. lead safe 3 in. deep neatly bossed at angles, and with the edges closely copper-nailed to the wood rim; fix from safe $1\frac{1}{2}$-in. lead waste pipe 14 lb. per yard carried through gable wall, over yard, and fitted with hinged copper flap valve at end; the boards and lead around outlet of safe to be slightly dished.

Water supply. Pay all fees, and connect to Water Company's main in road with screw ferrule, and lay on to cistern $\frac{3}{4}$-in. galvanized-iron service pipe, and dig for and lay same $2\frac{1}{2}$ ft. below finished surface of ground; at point near fence, where directed, fix $\frac{3}{4}$-in. stop cock approved by the Water Company in brick access pit, with iron cover and frame, and long wrought-iron key; at point where the pipe enters the scullery fix $\frac{3}{4}$-in. stop cock, as above, with porcelain enamelled label marked "No. 2", and over the scullery sink fix $\frac{3}{4}$-in. bib cock to empty the services, and behind this cock fix porcelain-enamelled label marked "Drinking Water", the supply pipe to be turned over into top of cistern, the wood cover being cut for the purpose.

Drill one cistern 4 in. from bottom and connect with $\frac{3}{4}$-in. brass boiler union, and carry $\frac{3}{4}$-in. lead pipe 9 lb. per yard down to the west bath room, and in this pipe, close to cistern, fix $\frac{3}{4}$-in. stop cock with porcelain-enamelled label marked "No. 3"; from this pipe run $\frac{3}{4}$-in. lead branches, as above, for cold supply to two baths and to sink in scullery, and $\frac{1}{2}$-in. do. 6 lb. per yard to three lavatories, sink in pantry, four W.C. cisterns, two points over sink in laboratory, and drip sink on second floor.

Fix *one* $\frac{3}{4}$-in. and *two* $\frac{1}{2}$-in. stop cocks, as above, on branch services, where directed, with porcelain-enamelled labels marked "No. 4", "No. 5", and "No. 6".

Hot-water services. Drill *bottom* of cistern and connect as before, and carry from same $1\frac{1}{4}$-in. lead pipe 16 lb. per yard, and connect to bottom of hot-water cylinder in scullery, and in this pipe, close to the cistern, fix $1\frac{1}{4}$-in. stop cock with loose spanner and porcelain-enamelled label marked "No. 7".

In scullery provide and fix on proper wrought fir bearers in cupboard a $\frac{3}{16}$-in.-plate galvanized wrought-iron cylinder 1 ft. 8 in. diameter and 4 ft. high to hold 53 gal., with manhole and bolted cover, indiarubber ring, and four screwed flanges.

Drill top of boiler in kitchen range, and connect with screwed union (which must not project inside the boiler) and $1\frac{1}{2}$-in. galvanized-iron flow pipe to side of cylinder, and with bend inside cylinder, and carried up half the height; from this pipe, in convenient position near boiler, fix $\frac{3}{4}$-in. tee piece and iron pipe fitted with $\frac{3}{4}$-in. gun-metal dead-weight safety valve; from bottom of cylinder to bottom of side of boiler fix $1\frac{1}{2}$-in. galvanized-iron return pipe having $1\frac{1}{4}$-in. to $\frac{3}{4}$-in. tee and $\frac{3}{4}$-in. cock with loose spanner at lowest point, for emptying boiler; fit up from top of cylinder $1\frac{1}{2}$-in. galvanized-iron rising main carried through roof and turned over at end, and from this pipe fit up 1-in. iron secondary flow through scullery, pantry, &c., to the back of linen cupboard, with return to cylinder or to main return pipe.

Note.—Round or square elbows must not be used in any of the flow and return pipes, but all changes of direction must be made with easy bends, and all pipes must be laid to rise from the boiler.

Setting out. Mark out the course for all hot-water pipes, and obtain the architect's approval before laying the pipes.

Temperature. The hot-water service will not be passed unless one bath can be filled up to the overflow with water at 120° F. after the kitchen fire has been burning for $1\frac{1}{2}$ hour, the water before the test being at the normal cold temperature.

Branch services. From the rising main or from the secondary flow fit up $\frac{3}{4}$-in. iron pipes for hot water to two baths and to sink in scullery, and $\frac{1}{2}$-in. do. to three lavatories, one drip sink on second floor, and to pantry sink, all the pipes to be as described above; fix in three branches, where directed, two $\frac{3}{4}$-in. and one $\frac{1}{2}$-in. stop cocks with labels enamelled "No. 8", "No. 9", and "No. 10".

Covering pipes, &c. Cover the cylinder and the primary and secondary flow and return pipes (but not the branches) with approved asbestos non-conducting

material on strong canvas backing securely fixed with strong wire or metal ribbon.

Baths. Provide and fix in each bath room a bath with fittings complete (p.c. £9), and allow for packing and carriage, &c.; fix under fittings only of each bath a safe of 5-lb. lead, 18 in. square inside and 3 in. deep, neatly bossed at angles, and with the edges closely copper-nailed to the wood rim, and fit up from same 1½-in. lead waste pipe 14 lb. per yard, with flap as described for cistern safe.

Fit up from the west bath to the iron rainwater head outside 1½-in. lead waste pipe 14 lb. per yard, and from the east bath to the iron rainwater pipe outside the laboratory 1½-in. galvanized-iron waste pipe with **Y**-pieces for connections of lavatory waste pipe and anti-siphonage pipe, and all necessary bends, hangers, &c.

Towel rails. Provide No. 2 towel rails (p.c. £4 each), and allow for package, carriage, and fixing with ¾-in. hot flow and return in iron.

Lavatories. Provide and fix three lavatories with skirting, fittings, rails and brackets (p.c. £3 per set complete), and allow for packing, carriage, &c., and fit up from each 1¼-in. lead trap with cleaning eye and waste pipe 11 lb. per yard, through wall to gully or iron waste pipe.

Sinks. Provide and fix in scullery one strong white glazed fireclay sink, 36 in. by 20 in. by 6 in., from an approved maker, and fit up to same two ¾-in. cocks enamelled "Hot" and "Cold", 3½-in. brass cobweb grating and lead cone, 1½-in. drawn-lead **S** trap with cleaning eye, and 1½-in. lead waste 14 lb. per yard, to gully outside.

Provide and fix in pantry and laboratory two white glazed fireclay sinks 30 in. by 18 in. by 10 in., with back overflows, brass washers, vulcanite plugs, flynuts, and unions (p.c. 30*s.* each), and allow for packing, carriage, &c., and fit up to pantry sink two ½-in. cocks enamelled "Hot" and "Cold", and to laboratory sink two ½-in. cocks not enamelled, each sink to have 1¼-in. trap and waste as specified for lavatories.

Line the drip sink on second floor with 8-lb. milled lead, bossed at angles, and properly dressed over the wood frame, and fit up from same 1½-in. lead trap with cleaning eye, and 1½-in. waste pipe 14 lb. per yard to the rainwater head outside the bath room below; the outlet from the sink to have 3-in. brass cobweb grating, and the lead to be dished around the grating.

Water closets. Provide and fix No. 4 sets W.C. apparatus with waste preventers and brackets, and seats and brackets (average p.c. £5 the set complete). Put to each 1½-in. lead flush pipe 14 lb. per yard. Those on ground floor to be connected to bend of drain with neat Portland cement above the level of floor, and those on first floor to be connected to soil pipe with 3½-in. drawn-lead bend (equal to 8-lb. lead) having strong brass socket and sleeve wiped on the ends, the socket to be connected to closet with yarn and neat Portland cement and the sleeve to be connected to iron soil-pipe branch with caulked blue-lead joint.

Overflow pipes. Fit up from four W.C. cisterns ¾-in. light lead overflow pipes carried through the walls where directed.

Soil pipe. Fit up one stack of 3½-in. round cast-iron soil pipe to L.C.C. requirements, with easy bend and foot rest at bottom bedded on Portland cement concrete 6 in. thick, 3½-in. curved junction and 3½-in. bends as shown, and copper wire dome guard at top, all the pipes and fittings to be coated with Angus Smith's solution, and all joints to be made thoroughly tight with yarn and blue lead well caulked. That on slope of roof to have wood blocks and 6-lb. lead tiles to support same.

Anti-siphonage pipes. Fit up from the branches of two W.C.'s on the first floor 2-in. lead anti-siphonage pipes with wiped joints, and make one connection into reversed junction in iron soil pipe with brass sleeve piece wiped on and caulked with blue lead.

Fit up from the waste pipes of bath and lavatory in east bath room 1-in. middling lead anti-siphonage pipes, 9 lb. per yard, with wiped junction, and carry up one pipe through the main lead flat, which must be cut and tafted up and wiped to the pipe.

TAKING-OFF

			CISTERN AND SUPPLY
	2/		Wrought-iron galvanized and riveted cisterns ⅛-in. plate, each to hold 150 gal., and hoisting and fixing on second floor.
	1/		Connecting two cisterns with length of 1¼-in. galvanized steam pipe and flynut between, and holes in cisterns.
	6·0		1½-in. lead overflow pipe *from Cistern.*
	2/		Bends.
	1/		1½-in. brass boiler screw with union, flynut, and washer for iron cistern, including hole in cistern and soldered joint.
			Size of Safe, 4′ 0″ × 6′ 6″; *Turn-up,* 2/3″ = 6″ 2/3″ = 6″; 4′ 6″ 7′ 0″
	4·6 7·0	31·6	5-lb. lead safe.
	21·0		Close copper-nailing.
	4/		Bossed angles to safes 3 in. high.
	9·0		1½-in. lead overflow a.b. (*i.e.* as before) *from Safe.*
	1/		Tafted and soldered joint.
	1/		Copper-hinged flap and soldering to 1½-in. pipe.
	50·0		¾-in. galvanized-iron steam tubing and laying in trench, and Digging trench not less than 2 ft. 6 in. deep for service pipe, &c., filling in and ramming and making good surface. *Rising main.* NOTE.—This is an imaginary length from the boundary of site up to point where rising main enters building. Allow for the requisite length of ¾-in. service pipe from main in road up to boundary of site, including opening up road and path, and screw ferrule, and drilling and tapping main, and all watching and lighting, and pay all fees.
	42·0		¾-in. G.I. steam tubing and fixing with holdfasts *to Cistern.*
	1/		¾-in. full-way equilibrium ball valve with strong lever and large copper ball, screw ferrule, flynut and union, screwed for iron pipe, and hole in cistern.
	1/		¾-in. stop cock approved by the Water Company, screwed for iron both ends, and with long wrought-iron key.
	1/		Brick access pit for do., 2 ft. 6 in. deep, with rendered concrete bottom and iron cover and frame.
	1/		¾-in. bib cock screwed for iron. *Scullery.*
	1/		¾-in. T *for last.*
			SERVICES
	1/		¾-in. boiler screw, &c., a.b.
			From Cistern to West Wall, 14′ 0″ *To point over Angle of West Bath Room,* 17′ 0″ *To Bath-room Floor,* 10′ 0″ *To point over Scullery Sink,* 18′ 0″ *Down to do.* 8′ 0″ 67′ 0″

	67·0		$\frac{3}{4}$-in. lead service (9 lb. per yard) and fixing with holdfasts, &c.	
	1·1/	= 2	$\frac{3}{4}$-in. stop cock soldered both ends.	
	2/		$\frac{1}{2}$-in. do.	
	3·0	3·0	$\frac{3}{4}$-in. lead service as last	*to West Bath.*
				17′ 0″ 17′ 0″ 10′ 0″ 44′ 0″
	44·0	44·0	Add	*to East Bath.*
		47·0		
	2/		Soldered joints.	
	2/		Do. to brass work	*to Bath fittings.*
	1·2/	= 3	Soldered stopped ends.	*1 added for Scullery.*
	8·0		$\frac{1}{2}$-in. lead service (6 lb. per yard)	*to Pantry from $\frac{3}{4}$-in. service.*
2/	7·0	14·0	$\frac{1}{2}$-in. service as last.	*First-floor Lavatories from $\frac{3}{4}$-in. services.*
	16·0	16·0	Add	*Ground-floor Lavatory from $\frac{1}{2}$-in. service to Pantry.*
				17′ 0″ 5′ 0″ 5′ 0″ 3′ 0″ 7′ 0″ 37′ 0″
	37·0	37·0	Add	*Laboratory from $\frac{3}{4}$-in. service.*
3/	3·0	9·0	Add	*to W.C.'s from nearest services.*
				19′ 0″ 3′ 0″ 3′ 0″ 25′ 0″
	25·0	25·0	Add	*to Servants' W.C. from $\frac{3}{4}$-in. service.*
				11′ 0″ 4′ 0″ 15′ 0″
	15·0	15·0	Add	*to Drip Sink from $\frac{3}{4}$-in. service.*
		116·0		
	4/		$\frac{1}{2}$-in. soldered joints.	
	6/		$\frac{3}{4}$-in. do.	
	10/		$\frac{1}{2}$-in. soldered stopped ends.	
	7/		$\frac{1}{2}$-in. soldered joints to brass work.	*Lavatories and W.C.'s.*
			HOT-WATER SERVICES	
	1/		$1\frac{1}{4}$-in. boiler screw, &c., a.b.	*Cold Service to Hot Water.*
	35·0		$1\frac{1}{4}$-in. lead service pipe (16 lb. per yard), and fixing, &c.	
	1/		Connection of do. to flange of H.-W. cylinder.	
	1/		$1\frac{1}{4}$-in. stop cock a.b., but with loose key.	

	1/		$\frac{3}{16}$-in. plate galvanized wrought-iron cylinder, 1·8 diameter and 4 ft. high, to hold 53 gal., with manhole and bolted cover, india-rubber ring and four screwed flanges, and fixing in cupboard in scullery, including fir bearers.	
	2/		$1\frac{1}{2}$-in. screwed unions (which must not project inside the boiler) screwed for iron, including drilling boiler.	
2/	20·0		$1\frac{1}{2}$-in. G.I. steam pipe in hot-water service.	*Flow and Return to Boiler.*
	1·2/	=3	Connection of last with union of cylinder.	
	1·1/	=2	$1\frac{1}{2}$-in. T	*for Safety Valve.* *1 added for draw-off.*
	6·0		$\frac{3}{4}$-in. G.I. steam pipe.	*for Safety Valve.*
	1/		$\frac{3}{4}$-in. gun-metal dead-weight safety valve in iron case, and fixing.	
	1/		$\frac{3}{4}$-in. brass bib cock with loose spanner, and screwed for iron.	
	22·0		$1\frac{1}{2}$-in. G.I. steam pipe.	*Rising Main.*
	1/		Bend at top. NOTE.—Connection to cylinder added above.	
	1/		Hole through tiled roof for $1\frac{1}{2}$-in. galvanized-iron pipe, including lead collar soldered on, and making good.	*From Cylinder to Linen,* 42′ 0″ *Across to Pantry Sink,* 17′ 0″ *Up Linen Cupboard,* 5′ 0″ = 64′ 0″
2/	64·0	128·0	1-in. G.I. steam pipe.	*Flow and Return.*
	1/		Connection of last to union of cylinder.	
	8·0	8·0	$\frac{3}{4}$-in. G.I steam pipe.	*Service to Baths.*
	6·0	6·0	Add	
		14·0		
	1·2/	= 3	1-in. Tees.	
	7·0	7·0	$\frac{3}{4}$-in. G.I. steam pipe. NOTE.—T added.	*Scullery Sink.*
	17·0	17·0	$\frac{1}{2}$-in. G.I. steam pipe.	*Ground-floor Lavatory.*
2/	5·0	10·0	Add	*First-floor Lavatories.*
	7·0	7·0	Add	*Pantry.*
	30·0	30·0	Add	*to Draw-off.*
		64·0		
	2/		$\frac{3}{4}$-in. Tees.	
	4/		1-in. Do.	
	2/		$\frac{3}{4}$-in. stop cocks screwed for iron both ends.	
	1/		$\frac{1}{2}$-in. Do.	
	2/		Connections of $\frac{3}{4}$-in. G.I. steam pipe to fittings.	
	3/		Do. $\frac{1}{2}$-in. do.	
2/2/	6·0	24·0	$\frac{3}{4}$-in. galvanized steam pipe	*to Towel Rails.*

	2/2/	= 4	1-in. Tees.
	2/		Towel rails (p.c. £4 each), and include for package, carriage, and fixing.
			FITTINGS AND WASTES
2/	10·0	20·0	Covering pipes with approved asbestos non-conducting material on strong canvas backing, securely fixed with strong wire or metal ribbon.
	22·0	22·0	
2/	64·0	128·0	
		170·0	
	1/		Covering as last, to cylinder.
	2/		Baths (p.c. £9 each), and include for package, carriage, and fixing.
			Size of safe, 1′ 6″ *Turn-up,* 2/3″ = 6″ 2′ 0″
2/	2·0 2·0	8·0	5-lb. lead safe.
2/	8·0	16·0	Close copper-nailing.
	2/4/	= 8	Bossed angles to safe, a.b.
	22·0		$1\frac{1}{2}$-in. lead waste pipe (14 lb. per yard) and fixing (bends measured).
	4·0		
	2/		Tafted and soldered joints.
	2·4/	= 6	Bends.
	2/		Copper flaps to $1\frac{1}{2}$-in. pipe, a.b.
	4·0		$1\frac{1}{2}$-in. lead waste pipe a.b. *West Bath.*
	2/		Bends.
	1/		Soldered joint to brass work.
	27·0		$1\frac{1}{2}$-in. galvanized-iron waste pipe and fixing between joists, with all necessary hangers, &c.
	2/		$1\frac{1}{2}$-in. **Y** junctions.
	1/		Connection to bath trap.
	3/		Lavatories, with skirtings, fittings, rails and brackets (p.c. £3 the set complete), and include for package, carriage, and fixing, and plugging brackets.
	3/		$1\frac{1}{4}$-in. drawn-lead **S** or **P** traps with brass cleaning screw and soldered joint both ends.
	4·0		$1\frac{1}{4}$-in. lead waste pipe (11 lb. per yard) and fixing.
	8·0		
	10·0		
	1/		Connection to arm of gully in neat cement.
	1/		Connection of $1\frac{1}{4}$-in. lead pipe to junction in steam pipe.
	1/		Strong white glazed fireclay sink 36 in. by 20 in. by 6 in., from an approved maker, and fixing. *Scullery.*

	1/		¾-in. bib cock enamelled "Cold" and soldering.
	1/		Do. enamelled "Hot" and screwed for iron (*with hot-water work*).
	1/		3½-in. fine brass cobweb grating, including lead cone and soldering and fixing in stoneware sink.
	1/		1½-in. S or P trap a.b.
	4·0		1½-in. lead waste pipe (14 lb. per yard) and fixing.
	2/		Bends.
	1/		End connected to arm of gully a.b.
	2/		White glazed fireclay sinks, 30 in. by 18 in. by 10 in., with back overflow, brass washer, vulcanite plug, flynut and union (p.c. 30*s.* each), and include for package, carriage, and fixing. *Pantry and Laboratory.*
	2/		½-in. bib cocks and soldering.
	1/		Do. enamelled "Cold".
	1/		Do. enamelled "Hot" and screwed for iron (*with hot-water work*).
	4·0		1¼-in. lead waste pipe as before.
	10·0		
	2/		1¼-in. S or P traps a.b. NOTE.—*Gratings added.*
			Drip Sink.
			Size of sink, 2′ 6″ × 1′ 6″
			Turn-up, 2/9″ = 1′ 6″ 2/9″ = 1′ 6″
			4′ 0″ 3′ 0″
	4·0 3·0	12·0	8-lb. lead lining to sink.
	4/		Bossed angles 9 in. high.
	8·0		Close copper-nailing.
	17·0		1½-in. lead waste pipe (14 lb. per yard) and fixing.
	3/		Bends.
	1/		1½-in. trap a.b.
	1/		1½-in. tafted and soldered joint.
	1/		3 in. brass fine cobweb grating, and soldering in lead sink.
	4/		W.C. apparatus, including water waste preventer and brackets, and seat and brackets (average p.c. £5 the set complete), and include for package, carriage, and fixing, including plugging brackets.
4/	7·0	28·0	1½-in. flush pipe (14 lb. per yard) and fixing.
	4/3/	= 12	Bends.
	4/		Soldered joints to brass work.
	4/		Connections of 1½-in. lead flush pipe to trap of W.C. 9′ 0″ 5 0″ 14′ 0″ 7′ 0″

	2/		$3\frac{1}{2}$-in. drawn-lead outlet bends from W.C., average 7 ft. long (equal in thickness to 8-lb. lead), with strong brass socket and sleeve wiped on the ends, the socket to be connected to closet with yarn and neat Portland cement, and the sleeve to be caulked with blue lead into iron soil pipe branch, and fixing to facing. *First-floor W.C.'s.*
	2/		Connections of W.C.'s to bend of iron drain in neat cement. *Ground-floor W.C.'s.*
	4/		2 ft. 6 in. lengths of $\frac{3}{4}$-in. lead overflow pipe with soldered joint to waste preventer.
	21·0		$3\frac{1}{2}$-in. round C.I. soil and vent pipe to L.C.C. requirements, coated with Dr. Angus Smith's solution. All pipes made thoroughly tight with yarn and blue lead, and fixed to facing with strong nails to stand 1 in. clear of walls, including all short lengths.
	12·0		Do. but fixed to tiled roof, including wood blocks, 6-lb. lead tiles, &c., complete, and making good around.
	4/		Extra to obtuse bends.
	2/		Do. to junctions.
	1/		Do. to reversed junctions with 2″ arm.
	1/		Do. to swan neck $4\frac{1}{2}$-in. projection.
	1/		Extra to easy bend and foot rest at bottom, bedded in cement concrete 6 in. thick.
	1/		Copper wire balloon grating, and fixing on top of $3\frac{1}{2}$-in. vent pipe.
	1/		Hole through tiled roof for soil pipe, including lead collar and soldering and making good.
			ANTI-SIPHONAGE PIPES
	8·0	8·0	2-in. lead pipe (24 lb. per yard) and fixing *to W.C.'s.*
	3·0	3·0	Add
		11·0	
	1/		Bend.
	3/		Solder joints.
	1/		Connection of 2-in. lead pipe to reversed junction in iron soil pipe, with wiped soldered joint, and strong brass sleeve piece caulked with blue lead into junction.
	20·0	20·0	1-in. lead anti-siphonage pipe (9 lb. per yard) and fixing. *Bath and Lavatory.*
	14·0	14·0	Add
		34·0	
	1/		End connected to junction in iron waste pipe.
	2/		1-in. soldered joints.
	1/		Hole through lead flat for 1-in. pipe and tafted joint.
			LABELS
	9/		Porcelain enamelled labels for cocks, lettered "No. 2", &c.
	1/		Do. but lettered "Drinking Water".

Supers.
5-lb. lead safes.

31·6
8·0
39·6
× 5
198 lb.
96
294 lb.
cwt. 2·2·14.

8-lb. lead lining to sink.

12·0
× 8
96 lb.

Run.
Close copper-nailing.

21·0
16·0
8·0
45·0

Nos.
Bossed angles to safe, 3 in. high.

4
8
12

Do. to sink 9 in. high (in 8-lb. lead).

4

Runs.
1-in. lead waste pipes, &c. (9 lb. per yard), and fixing with all holdfasts, &c., and including ordinary joints, bends, &c.

34·0

1¼-in. do. (11 lb. per yard) do.

22·0
14·0
36·0

1½-in. do. (14 lb. per yard) do. (bends measured).

6·0
9·0
26·0
4·0
4·0
17·0
28·0
94·0

2-in. do. (24 lb. per yard) do. (do.).

11·0

½-in. lead service pipe (6 lb. per yard) do.

8·0
116·0
124·0

¾-in. do. (9 lb. per yard) do.

67·0
47·0
114·0

1¼-in. do. (16 lb. per yard) do

35·0

Nos.
Extra to bends in 1½-in. pipe.

2
6
2
2
3
12
27

Do. in 2-in. do.

1

Soldered stopped ends to ½-in. pipe.

10

Do. to ¾-in. do.

3

½-in. soldered branch joints.

4

¾-in. do.

2
6
8

1-in. do.

2

2-in. do.

3

½-in. soldered joints to brass work.

7

¾-in. do.

2

1½-in. do.

1
4
5

1½-in. tafted and soldered joints.

1
2
1
4

Hole through lead flat for 1-in. pipe and tafted joint.

1

Connection of 1-in. lead pipe to junction in G.I. steam tubing.

1

Do. of 1¼-in. do.

1

Connection of 1¼-in. lead pipe to flange of H.-W. cylinder.

1

Connection of 1¼-in. lead pipe to arm of gully in neat cement.

1

Do. of 1½-in. do.

1

Connection of 1½-in. lead flush pipe to trap of W.C.

4

Connection of 2-in. lead pipe to reversed junction in iron soil pipe with wiped soldered joint, and strong brass sleeve piece caulked with blue lead into junction.

1

Connection of W.C. to bend of iron drain pipe in neat cement.

2

Copper-hinged flaps and soldering to end of 1½-in. pipe.

1
2
3

3 in. fine brass cobweb grating, and soldering in lead sink.

1

3½-in. do., including lead cone and soldering and fixing in stoneware sink.

1

2 ft. 6 in. length of ¾-in. lead overflow pipe with soldered joint to waste preventer.

4

1¼-in. drawn-lead **S** or **P** traps, with brass cleaning screw and soldered joint both ends.

3
2
5

1½-in. do.

1
1
2

3½-in. drawn-lead outlet bend from W.C., average 7 ft. long, equal in thickness to 8-lb. lead, with strong brass socket and sleeve wiped on the ends, the socket to be connected to closet with yarn and neat Portland cement, and the sleeve to be caulked with blue lead into iron soil pipe branch, and fixing to facing.

2

Runs.
¾-in. G.I. steam tubing with bends, &c., as described, and laying in trench (as rising main).

50·0

¾-in. do. but fixed with holdfasts.

42·0

1½-in. do. but fixed between joists with all necessary hangers, &c.

27·0

Nos.
¾-in. Tee.

1

1½-in. **Y** junctions.

2

Connection of 1½-in. waste pipe to bath trap.

1

Runs.
3½-in. round cast-iron soil and vent pipe to L.C.C. requirements, coated with Dr. Angus Smith's solution. All pipes made thoroughly tight with yarn and blue lead, and fixed to facing with strong nails to stand 1 in. clear of walls, including all short lengths.

21·0
= 7 yd.

Do. do. but fixed to tile roof, including wood blocks, lead, tiles, &c., complete, and making good around.

12·0
= 4 yd.

Nos.
Extra to obtuse bends.

4

Do. to junctions.

2

Do. to reversed do.

1

Do. to swan neck 4½-in. projection.

1

Extra to easy bend and foot rest at bottom, bedded in cement concrete 6 in. thick.

1

Copper wire balloon grating, and fixing on top of 3½-in. vent pipe.

1

Hole through tiled roof for soil pipe, including lead collar, and soldering and making good.

1

To face p. 314.

$\frac{3}{4}$-in. brass boiler screw, with union and flynut and washer for iron cistern, including hole in cistern and soldered joint.

1 $1\frac{1}{4}$-in. do.

1 $1\frac{1}{2}$-in. do.

1

$\frac{1}{2}$-in. bib cocks and soldered joints.

2 $\frac{1}{2}$-in. do. enamelled "Cold" and do.

1 $\frac{3}{4}$-in. do. do. and do.

1

$\frac{3}{4}$-in. bib cock screwed for iron.

1

$\frac{1}{2}$-in. stop cock soldered both ends.

2 $\frac{3}{4}$-in. do.

2 $1\frac{1}{4}$-in. do. with loose key.

1

$\frac{3}{4}$-in. stop cock screwed for iron both ends.

1 $\frac{3}{4}$-in. stop cock approved by the Water Company, screwed for iron both ends, and with long W.I. key.

1 Brick access pit for do. 2 ft. 6 in. deep, with rendered concrete bottom, and iron cover and frame.

1

$\frac{3}{4}$-in. full-way equilibrium ball valve with strong lever and large copper ball, screw ferrule, flynut and union, screwed for iron pipe, and hole in cistern.

1 Porcelain enamelled labels for cocks, lettered "No. 2", &c.

9 Do. but lettered "Drinking Water".

1

W.I. galvanized and riveted cisterns $\frac{1}{8}$-in. plate, to hold 150 gal. each, and hoisting and fixing on second floor.

2 Connecting two cisterns with union in each, and length of $1\frac{1}{4}$-in. galvanized steam pipe between, and holes in cisterns.

1

Strong white glazed fireclay sink 36 in. by 20 in. by 6 in., from an approved maker, and fixing.

1 Do. 30 in. by 18 in. by 10 in. with back overflows, brass washers, vulcanite plugs, flynuts and unions, p.c. 30s. each, and include for package, carriage, and fixing.

2

W.C. apparatus including water waste preventers and brackets, and seats and brackets (average p.c. £5 the set complete), and include for package, carriage, and fixing, and plugging brackets.

4

Lavatories with skirting, fittings, rails and brackets (p.c. £3 the set complete), and include as above, and for plugging brackets.

3 Baths and fittings complete, p.c. £9 each, and include for package, carriage, and fixing.

2

Run.

Digging trench not less than 2 ft. 6 in. deep for service pipe, filling in and ramming, and making good surface.

50·0

17 yards.

Allow for the requisite length of $\frac{3}{4}$-in. service pipe from main in road up to boundary of site, including opening up road and path, and screw ferrule, and drilling and tapping main, and all watching and lighting, and pay all fees.

Runs.

$\frac{1}{2}$-in. galvanized-iron steam tubing with bends, &c., and fixing.

64·0 $\frac{3}{4}$-in. do.

6·0
14·0
7·0
24·0

51·0

1-in. do.

128·0 $1\frac{1}{2}$-in. do.

20·0
22·0

42·0

Nos.

$\frac{3}{4}$-in. tees.

2 1-in. do.

3
4
4

11

$1\frac{1}{2}$-in. do.

2

Bends at top of $1\frac{1}{2}$-in. pipe.

1

Connections of $\frac{1}{2}$-in. pipe to lavatory fittings.

3 Do. of $\frac{3}{4}$-in. do. to bath fittings.

2 Do. of 1-in. do. to union of cylinder.

1 Do. of $1\frac{1}{2}$-in. do. to do.

3

Hole through tiled roof for $1\frac{1}{2}$-in. galvanized iron pipe including lead collar soldered on, and making good.

1

$1\frac{1}{2}$-in. screwed unions (which must not project inside boiler), screwed for iron, including drilling boiler.

2

$\frac{1}{2}$-in. bib cock enamelled "Hot", screwed for iron.

1 $\frac{3}{4}$-in. do.

1 $\frac{3}{4}$-in. bib cock with loose spanner, and screwed for iron.

1

$\frac{1}{2}$-in. stop cock screwed for iron both ends.

1 $\frac{3}{4}$-in. do.

2

$\frac{3}{4}$-in. gun-metal dead-weight safety valve in iron case, and fixing.

1

Towel rails, p.c. £4 each, and include for package, carriage, and fixing.

2

$\frac{3}{16}$-in. plate galvanized W.I. cylinder, 1 ft. 8 in. diameter and 4 ft. high, to hold 53 gal., with manhole and bolted cover, indiarubber ring and four screwed flanges, and fixing in cupboard in scullery, including fir bearers.

1

Run.

Covering pipes with approved asbestos non-conducting material on strong canvas backing, securely fixed with strong wire or metal ribbon.

170·0 Do. cylinder.

1

BILLING

All lead to be best milled and of the full weights specified.

Lead pipes to be the best drawn, all dimensions given being internal, and to be laid complete with all necessary running joints, holdfasts, lead tacks, &c., and so as to empty themselves.

All solder joints to be "wiped".

All cocks to be best full-way high-pressure screw-down in gun metal, from an approved maker, with screwed bosses.

All iron pipes to be best galvanized wrought-iron steam tubing fitted with bends, short pieces, and all necessary connectors, galvanized holdfasts, &c.

Cwt.	qr.	lb.				£	s.	d.
2	2	14		Milled lead and labour in safes and sink	32/6	4	5	4
	Ft.							
	45		Run	Close copper-nailing	/2$\frac{1}{2}$		9	5
		No.	12	Bossed angles to safes 3 in. high	/5		5	0
			4	Do. to sink 9 in. high (8-lb. lead)	1/		4	0
	34		Run	1-in. lead anti-siphonage pipe, 9 lb. per yard, and fixing, with all holdfasts, &c., and including all ordinary joints, bends, &c.	1/1$\frac{1}{2}$	1	18	3
	36		"	1$\frac{1}{4}$-in. do. (11 lb. per yard) and do.	1/4	2	8	0
	94		"	1$\frac{1}{2}$-in. do. (14 lb. per yard) and do. (bends measured)	1/8	7	16	8
	11		"	2-in. do. (24 lb. per yard) and do. (do.)	2/7	1	8	5
	124		"	$\frac{1}{2}$-in. lead service pipe (6 lb. per yard) and fixing, with all holdfasts, and including ordinary joints, bends, &c.	/9$\frac{1}{2}$	4	18	2
	114		"	$\frac{3}{4}$-in. do. (9 lb. per yard) do.	1/0$\frac{1}{2}$	5	18	9
	35		"	1$\frac{1}{4}$-in. do. (16 lb. per yard) do.	1/8	2	18	4
		No.	27	Extra to bends in 1$\frac{1}{2}$-in. lead pipe	1/	1	7	0
			1	Do. to do. in 2-in. do.	1/6		1	6
			10	Soldered stopped ends to $\frac{1}{2}$-in. pipe	/9		7	6
			3	Do. to $\frac{3}{4}$-in. do.	1/		3	0
			4	$\frac{1}{2}$-in. soldered branch joints	1/4		5	4
			8	$\frac{3}{4}$-in. do.	1/7		12	8
			2	1-in. do.	1/10		3	8
			3	2-in. do.	2/9		8	3
			7	$\frac{1}{2}$-in. do. to brass work	1/6		10	6
			2	$\frac{3}{4}$-in. do. do.	1/9		3	6
			5	1$\frac{1}{2}$-in. do. do.	2/9		13	9
			4	1$\frac{1}{2}$-in. tafted and soldered joints	2/		8	0
			1	Hole through lead flat for 1-in. pipe and tafted joint	2/		2	0
			1	Connection of 1-in. lead pipe to junction in galvanized-iron waste pipe	/6			6
			1	Do. of 1$\frac{1}{4}$-in. do. to do.	/6			6
			1	Connection of 1$\frac{1}{4}$-in. lead pipe to flange of hot-water cylinder	5/9		5	9
			1	Connection of 1$\frac{1}{4}$-in. do. to arm of gully in neat cement	/6			6
			1	Do. of 1$\frac{1}{2}$-in. do. to do.	/6			6
			4	Do. of 1$\frac{1}{2}$-in. lead flush pipe to trap of W.C.	1/6		6	0
			1	Connection of 2-in. lead pipe to reversed junction in iron soil pipe, with wiped soldered joint and strong brass sleeve piece caulked with blue lead into junction	5/6		5	6
			2	Connections of trap of W.C. to iron bend of drain pipe in neat cement	/9		1	6
			3	Copper-hinged flaps and soldering to end of 1$\frac{1}{2}$-in. pipe	1/6		4	6
			1	3-in. fine brass cobweb grating, and soldering in lead sink	2/6		2	6
				Carried forward		39	4	9

					£	s.	d.
			Brought forward		39	4	9
	No.	1	$3\frac{1}{2}$-in. do., including lead cone and soldering, and fixing in stoneware sink	7/3		7	3
		4	2 ft. 6 in. lengths of $\frac{3}{4}$-in. lead overflow pipe with soldered joint to waste preventers	3/3		13	0
		5	$1\frac{1}{4}$-in. drawn lead **S** or **P** traps with brass cleaning screw and soldered joint both ends	3/4		16	8
		2	$1\frac{1}{2}$-in. do. do.	4/		8	0
		2	$3\frac{1}{2}$-in. drawn-lead outlet bend from W.C., average 7 ft. long (equal in thickness to 8-lb. lead), with strong brass socket and sleeve wiped on the ends, the socket to be connected to closet with yarn and neat portland cement, and the sleeve to be caulked with blue lead into iron soil pipe branch, and fixing to facing	43/	4	6	0
Ft.							
50		Run	$\frac{3}{4}$-in. galvanized-iron steam tubing with bends, &c., as described, and laying in trench (as rising main) ...	/$6\frac{1}{2}$	1	7	1
42		"	$\frac{3}{4}$-in. steam tubing as last, but fixed with holdfasts ...	/$7\frac{1}{2}$	1	6	3
27		"	$1\frac{1}{2}$-in. do. but fixed between joists with all necessary hangers, &c.	1/$4\frac{1}{2}$	1	17	2
	No.	1	$\frac{3}{4}$-in. tee	/10			10
		2	$1\frac{1}{2}$-in. **Y** junctions	2/		4	0
		1	Connection of $1\frac{1}{2}$-in. galvanized-iron pipe to bath trap	1/6		1	6
21		Run	$3\frac{1}{2}$-in. round cast-iron soil and vent pipe to L.C.C. requirements, coated with Dr. Angus Smith's solution. All pipes made thoroughly tight with yarn and blue lead, and fixed to facing with strong nails to stand 1 in. clear of walls, including all short lengths.	1/$4\frac{1}{2}$	1	8	11
12		"	Do. do. but fixed to tiled roof, including wood blocks, lead tiles, &c., complete, and making good around	2/3	1	7	0
	No.	4	Extra to obtuse bends	2/9		11	0
		2	Do. to junctions	5/3		10	6
		1	Do. to reversed do. with 2 in. arm	4/9		4	9
		1	Do. to swan neck, $4\frac{1}{2}$-in. projection	3/3		3	3
		1	Do. to easy bend and foot rest at bottom, bedded in cement concrete 6 in. thick	4/6		4	6
		1	Copper-wire balloon grating, and fixing on top of $3\frac{1}{2}$-in. vent pipe	1/9		1	9
		1	Hole through tiled roof for soil pipe, including lead collar and soldering, and making good	8/9		8	9
		1	$\frac{3}{4}$-in. brass boiler screw with union, flynut, and washer for iron cistern, including hole in cistern and soldered joint	3/3		3	3
		1	$1\frac{1}{4}$-in. do. do.	5/4		5	4
		1	$1\frac{1}{2}$-in. do. do.	6/8		6	8
		2	$\frac{1}{2}$-in. bib cocks and soldered joints	3/9		7	6
		1	$\frac{1}{2}$-in. do. enamelled "Cold" and do.	4/6		4	6
		1	$\frac{3}{4}$-in. do. do. and do.	5/6		5	6
		1	$\frac{3}{4}$-in. bib cock screwed for iron	4/		4	0
		2	$\frac{1}{2}$-in. stop cock soldered both ends	5/8		11	4
		2	$\frac{3}{4}$-in. do.	7/7		15	2
		1	$1\frac{1}{4}$-in. do. with loose key	17/3		17	3
		1	$\frac{3}{4}$-in. do. screwed for iron both ends	4/9		4	9
		1	$\frac{3}{4}$-in. stop cock approved by the Water Company, screwed for iron both ends, and with long wrought-iron key	8/3		8	3
		1	Brick access pit for last, 2 ft. 6 in. deep, with rendered concrete bottom, and iron cover and frame ...	12/6		12	6
		1	$\frac{3}{4}$-in. full-way equilibrium ball valve with strong lever and large copper ball, screw ferrule, flynut, and union, screwed for iron pipe, and hole in cistern ...	9/6		9	6
		9	Porcelain enamelled labels for cocks, lettered "No. 2", &c.	1/6		13	6
		1	Do. but lettered "Drinking Water"	1/9		1	9
			Carried forward		62	3	8

					£	s.	d.
			Brought forward		62	3	8
	No.	2	Wrought-iron galvanized and riveted cisterns, $\frac{1}{8}$-in. plate, each to hold 150 gal., and hoisting and fixing on second floor	2/12/6	5	5	0
		1	Connecting two cisterns with length of 1$\frac{1}{4}$-in. galvanized steam pipe with flynuts between, and holes in cisterns	5/		5	0
		1	Strong white glazed fireclay sink 36 in. by 20 in. by 6 in., from an approved maker, and fixing ...	41/6	2	1	6
		2	Do., 30 in. by 18 in. by 10 in., with back overflows, brass washers, vulcanite plugs, flynuts, and unions, p.c. £1, 10*s.* each complete, and include for package, carriage, and fixing	38/	3	16	0
		4	W.C. apparatus, including water waste preventers and brackets, and seats and brackets, average p.c. £5 the set, and include for package, carriage, and fixing, and plugging brackets	6/5/0	25	0	0
		3	Lavatories, with skirtings, fittings, rails, and brackets, p.c. £3 the set, complete, and include as above ...	3/10/0	10	10	0
		2	Baths and fittings complete, p.c. £9 each, and include for package, carriage, and fixing	10/8/0	20	16	0
Yds. 17		Run	Digging trench not less than 2 ft. 6 in. deep for pipe, and filling in and ramming, and making good surface	1/6	1	5	6
			Allow for the requisite length of $\frac{3}{4}$-in. service pipe from main in road up to boundary of site, including opening up road and path, and screw ferrule, and drilling and tapping main, and all watching and lighting, and pay all fees (see note at end) ...		4	5	0
			HOT-WATER WORK				
			Round or square elbows must not be used, but all changes of direction must be made with easy bends, and all pipes must be laid to rise from the boiler.				
			Mark out the course for all hot-water pipes, and obtain the architect's approval before laying the pipes.				
			The hot-water service will not be passed unless one bath can be filled up to the overflow with water at 120° F., after the kitchen fire has been burning for 1$\frac{1}{2}$ hour, the water before the test being at the normal cold temperature.				
Ft. 64		Run	$\frac{1}{2}$-in. galvanized-iron steam tubing with bends, &c., and fixing as described	/6$\frac{1}{2}$	1	14	8
51		"	$\frac{3}{4}$-in. do. and do.	/7$\frac{1}{2}$	1	11	11
128		"	1-in. do. and do.	/9$\frac{1}{2}$	5	1	4
42		"	1$\frac{1}{2}$-in. do. and do.	1/1$\frac{1}{2}$	2	17	9
	No.	2	$\frac{3}{4}$-in. tees	/10		1	8
		11	1-in. do.	1/3		13	9
		2	1$\frac{1}{2}$-in. do.	2/		4	0
		1	Bend at top of 1$\frac{1}{2}$-in. pipe	1/6		1	6
		3	Connections of $\frac{1}{2}$-in. pipe to lavatory fittings	2/		6	0
		2	Do. of $\frac{3}{4}$-in. do. to bath fitting	2/6		5	0
		1	Do. of 1-in. do. to union of cylinder	3/6		3	6
		3	Do. of 1$\frac{1}{2}$-in. do. to do.	4/6		13	6
		1	Hole through tiled roof for 1$\frac{1}{2}$-in. steam pipe, including lead collars soldered on, and making good ...	6/3		6	3
		2	1$\frac{1}{2}$-in. screwed unions (which must not project inside boiler) screwed for iron, including drilling boiler ...	3/6		7	0
		1	$\frac{1}{2}$-in. bib cock enamelled "Hot", screwed for iron ...	3/6		3	6
		1	$\frac{3}{4}$-in. do. do.	4/7		4	7
			Carried forward		150	3	7

					£	s.	d.
			Brought forward		150	3	7
	No.	1	$\frac{3}{4}$-in. brass bib cock with loose spanner, and screwed for iron	4/		4	0
		1	$\frac{1}{2}$-in. stop cock screwed for iron both ends	3/6		3	6
		2	$\frac{3}{4}$-in. do. do.	4/10		9	8
		1	$\frac{3}{4}$-in. gun-metal dead-weight safety valve in iron case, and fixing	15/		15	0
		2	Towel rails, p.c. £4 each, and include for package, carriage, and fixing	4/15/	9	10	0
		1	$\frac{3}{16}$-in. plate galvanized wrought-iron cylinder, 1 ft. 8 in. diameter and 4 ft. high, to hold 53 gal., with man-hole and bolted cover, indiarubber ring, and four screwed flanges, and fixing in cupboard in scullery, including fir bearers	4/15/	4	15	0
Ft. 170		Run	Covering pipes with approved asbestos non-conducting material on strong canvas backing, securely fixed with strong wire or metal ribbon	/6	4	5	0
		1	Do. cylinder do.	20/	1	0	0
					171	5	9

Note.—The prices of plumbers' materials are subject to great fluctuation[1]. In the two specimen bills of Quantities the lead work is priced on the basis of the rate of 22*s.* 6*d.* per cwt. for sheet lead. The prices generally allow for 10 per cent profit, but must be taken as approximate only for good work in London. Lower rates of wages are often paid in provincial towns and in country districts, and in such cases lower prices would be remunerative.

The item of length of service pipe from main to boundary is priced at the average rate obtainable in London, allowing for about 12 ft. of service.

In order that the pricing of the Bill may be as useful as possible the author has availed himself of the assistance of the Estimator to one of the largest firms of contractors in London, and his thanks are due to that gentleman for his assistance.

[1] See Plates XLVII and XLVIII, Appendix II.

SECTION XVI

SHOP MANAGEMENT AND BOOKKEEPING

BY

ALFRED C. BEAL

SECTION XVI

SHOP MANAGEMENT AND BOOKKEEPING

CHAPTER I

SHOP MANAGEMENT

During recent years the arrangement and management of factories and workshops have undergone a complete change, especially in relation to the trades referred to in these volumes. The change may be attributed to the great advance in the application of scientific principles in modern construction, the introduction of labour-saving machinery, foreign and home competition, and the supervision of factories now exercised by the state, as well as the raising of the standard of the artisan by education. It is now generally acknowledged by all employers that in order to maintain or improve their position it is necessary not only to obtain efficiency in their productions, but efficiency combined with economy. These essential conditions of success can only be obtained by a thorough system of organization and a careful study of every detail of each department of the business, so that overlapping of departmental work is avoided.

General Arrangement of Buildings.—It is a great advantage, both in economy and quality of production, that the workshops, stores, and offices should be conveniently arranged, well managed, and organized under a proper system. A small works, or even one with a considerable business which has been built up gradually from a small beginning without considering the advantage to be obtained by rearrangement, is most difficult to manage with economy, and under none but the most exceptional circumstances can it produce results to compete with a factory suitably designed and arranged for the special work to be undertaken. The general type of building for the plumbing and allied trades includes a workshop, one or more offices, a warehouse consisting of one or more floors in accordance with the requirements of the business, and occasionally a show room. For the purpose of this article it will be advisable to take one building of three floors, the ground floor (fig. 1062) being divided into offices, show room, and loading dock for vans, the first floor (fig. 1063) being utilized as warehouse and stores, and the second floor (fig. 1064) as workshops for any artisans that may be employed either in manufacturing or repair work. In some cases the departments are arranged in separate buildings,

or are contained upon one floor. If the whole is arranged upon one floor it is necessary to divide it into sections for the different departments, as any attempt to combine stores and workshops is certain to prove wasteful, however small the scale upon which it is attempted.

The building must be efficiently lighted, warmed, and ventilated, and the necessary water-closets, urinals, washing accommodation, and water for drinking purposes must be provided in conformity with the Factory and Workshops Acts. These conveniences are not shown on the plans. They may be placed in a detached building in the back yard, but it is better to build a small wing behind the main building with conveniences on each floor. A lobby, properly lighted and ventilated, must be constructed between the conveniences and the main building on each floor.

The offices (fig. 1062) would be situated at one end of the building on the ground floor near the entrance, and should consist of a general office,

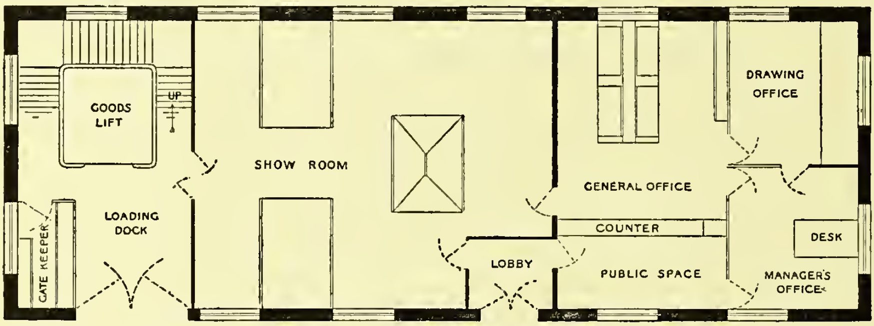


Fig. 1062.—Ground-floor Plan, showing Offices, Show Room, and Loading Dock

manager's office, and drawing office, the last being on the same floor and in connection with the other offices if possible; but if space is limited, it may be situated in another part of the building. The manager's office should be so arranged that it is possible to reach it without a stranger having to pass through the general office, but at the same time a door should be provided as a means of intercommunication between the manager and the clerical staff. One or more water-closets, lavatory basins, &c., must be provided in a convenient position, but properly disconnected from the offices.

A system of intercommunication telephones[1] is indispensable between the offices and the different departments of the works. The cost is small in comparison with the great advantages gained by a ready means of communication between the departments.

The show room would also be arranged upon the ground floor, and might, if necessary, occupy the whole of the remaining space to within 10 or 15 ft. of the further end of the building, which would be partitioned off to form a loading dock. The show room would be arranged with presses and shelves fitted in bays, if possible between the windows, in order to obtain the maximum advantages of space and light consistent with appearance. The goods displayed should be classified, and the fittings arranged to suit.

[1] See pages 347–356, Vol. II.

A loading dock is required for the receipt and despatch of goods. A lift for goods should be provided if possible, as well as a crane, to serve the floors above. Here also the entrance for employees would be situated. Of course these arrangements may have to be varied to suit existing circumstances if lifts, cranes, loops, &c., are already in existence in the building.

It would be necessary to have a small office in the loading dock for **the gatekeeper**, whose duties would include checking all goods received and passed out, arranging that all packages are properly despatched (if outwards), or (if inwards) forwarded to their proper departments. He would also act as timekeeper, checking all employees in and out of the building, and as craneman, if the gear is suitably arranged and the crane work not sufficiently constant to require a special attendant.

The stores (fig. 1063) should be divided into a series of pigeon holes or compartments of suitable sizes to take the various goods that it is necessary

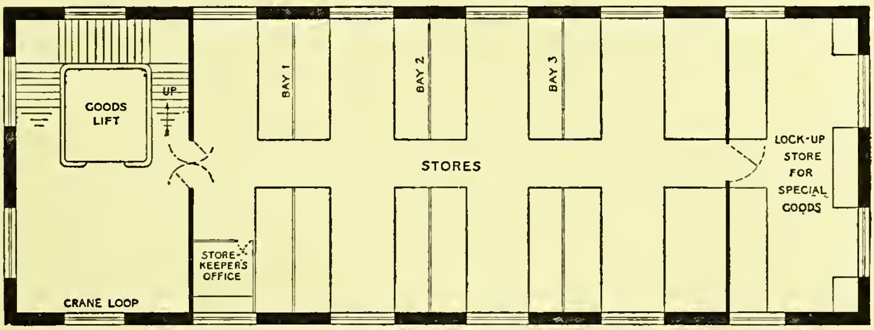


Fig. 1063.—First-floor Plan, showing Stores, &c.

to stock. A special position should be allocated for every article to be stocked, and the compartments, bins, racks, or shelves should be suitable for the different articles. Barrel and pipes generally stock better in an upright position in racks, the bundles or pipes being reversed in each tier, viz. with the socket and the spigot ends up alternately. Smaller goods, such as joints and fittings, taps, &c., stock better in compartments or bins. Nails and other goods of this description, likely to be used in larger quantities, should be stocked in bulk in the original packages, one package being kept open to draw from. Each compartment, bin, or shelf should be numbered, and each section should be lettered in bays; if this is carried out systematically, it reduces storekeeping costs to a minimum, and often saves much valuable time should the regular storekeeper be absent. An index key, arranged in alphabetical order, and containing particulars of the exact positions of the articles in stock, must be prepared, and it is recommended that this be arranged under a card system described later.

It is necessary to decide definitely **the maximum and minimum stocks** to be held of every different article. This being once settled, the stores will be found to work smoothly, and be capable of meeting, without extraordinary supervision, any reasonable demands which may be made upon them. The maximum and minimum stocks should be plainly marked on

a card in the front of each compartment, and the card should also show the size and description of the articles contained in the compartment.

The storekeeper should have two ordinary **carbon copy books,** one labelled *Inward Delivery Book* and the other *Outward Delivery Book,* and it should be his duty to enter up in these books all goods which are received into or passed out of the stores, and in the latter case the job for which the article is required. At the end of the day, these carbon copies should be detached from the books and handed into the general office to be dealt with, the outward delivery sheets being required by the prime-cost clerk, and the inward delivery sheets by the invoice clerk to check the invoices. These sheets should also contain complete lists of material returned from jobs, for the prime-cost clerks to credit, if special sheets are not provided for this purpose. All goods in the stores should be under the sole charge of the storekeeper.

In order to keep particulars of the stock held, **a card system,** having a separate card for each item in stock, is very useful. The cards may be ruled as illustrated below, and should be kept in the office, each card

CARD FOR GOODS IN STORES

Max. Stock.		ARTICLE.	Purchased from :—	Price.	Bay.	
Min. Stock.					Tier.	
					Compt. No.	

Date.	Received.	Number.	Date.	Out.	Number.

showing at the head the name and size of the article to which it applies, the maximum and minimum stocks to be held, the position in which the article is to be found in the stores (say, bay 2, tier E, No. 4), the name of the firm from whom the goods are generally ordered, and the price usually paid. Underneath these particulars, in columns specially ruled, would be shown the actual stock, and the several items in which the goods have been received into and delivered out of the stores, the dates of deliveries in and out, and the jobs for which the items were used, this information being obtained from the stores outward and inward delivery sheets. It is then possible to see at a glance the stock held of any particular goods. When the card is full it should be balanced and the stock in the corresponding compartment checked. The completeness of the system is not only a check upon the goods, but upon the storekeeper, clerks, and everyone concerned; the stocktaking is practically always up to date with the stores depart-

ment, and the annual stocktaking is much simplified, it being only necessary to check each card, and, if correct, balance, and carry the balance forward.

In the stores, **special tools**, such as Whitworth stocks and dies, taps, leather punches, files, &c., which would not be provided in every man's kit of tools, should be stored in proper racks. These tools would be booked out by the storekeeper, and credited by him when returned.

Arrangements should also be made to stock the **chests of tools** for outside work when not in use. It is good practice to provide each fitter with as complete a kit of tools as possible, including a screwing machine where wrought-iron pipe work of 1 in. and upwards is carried out; but special tools, such as large stocks and dies and cutters, should be issued only when the work upon which he is engaged requires them, and as soon as the fitter has completed the work for which they were issued, he should return them

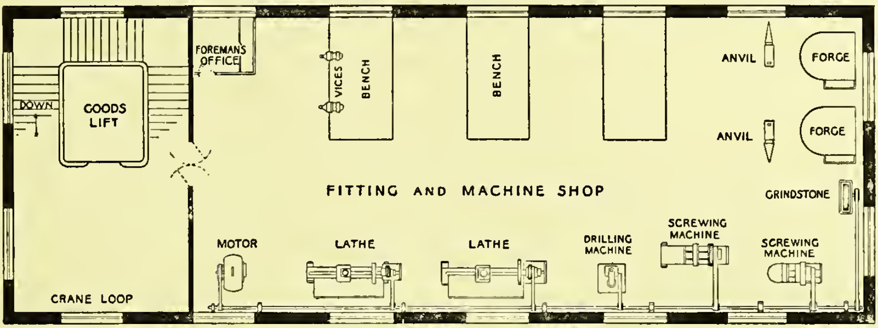


Fig. 1064.—Second-floor Plan, showing Workshop, &c.

in readiness for any demand that may be made in another direction. The kit of tools provided should be issued from the stores in a strong lock-up tool box. On the inner side of the lid or other conspicuous place should be fixed a list of tools contained in the kit. The fitter would then see that he obtained the complete set of tools, for which he would be responsible; when these were returned to the stores, the storekeeper would examine them and see that they were complete and in good order as sent out. Each kit should be numbered and the contents entered upon a card, which would be carried out as part of the system applying to the general stores. A rule should be made that all goods despatched from stores be booked out in detail; but in the case of kits of tools these should be entered out in one item (as, for example, Kit No. 1), but in every case the contents of the kit should be checked when issued out, and when returned to the stores. This would not apply to trades where the artisans engaged provide their own tools.

Special arrangements are necessary for **stocking sheet lead** according to the requirements. This is usually provided for upon the ground floor, as it is heavy to handle, and in many cases must be despatched in bulk. The lead would nevertheless be under the charge of the storekeeper. A floor or bench should be provided, close to the lead stores, sufficiently large to allow a full sheet to be laid out and dissected.

On the second floor (fig. 1064) **the workshop** is placed, and in it one or two light lathes would be provided, a drilling machine suitable for light repair work, and screwing machines suitable for screwing barrel from $\frac{1}{8}$-in. to 4-in. bore. For the smaller sizes a screwing machine fitted with solid dies will be found the most economical; for the larger sizes, (say) from $1\frac{1}{4}$ in. to 2 in., split dies will be more suitable, and for sizes from 2 in. to 4 in. concentric dies are better, as the work is much heavier. These machines should, if possible, be actuated by power; for this purpose a small electric motor or an oil or gas engine might be provided, and shafting would be suitably fixed as a means of distribution. Forges, brazing hearth, and appliances for melting and mixing soft metal should be arranged in convenient positions. Benches with fixed vices are required in this shop, so that any necessary fitting up and special repairs can be executed. The usual amount of bench room required per man is about 8 ft. by 2 ft. 6 in.

CHAPTER II

BOOKKEEPING, ACCOUNTS, ETC.

In controlling any business concern it is necessary to have a knowledge of bookkeeping and the preparation of accounts. By means of an accurate and complete system of bookkeeping, control can be kept over the affairs of the business, and it is possible to ascertain definitely what the firm possesses, and whether or not the state of the business will allow certain undertakings or investments to be entered into. It is a great safeguard against error and fraud, and also a means of discerning whether the work engaged in is profitable and should be pursued, or whether it is unprofitable and ought to be discontinued.

Bookkeeping is the process of reducing to writing and recording in books the accounts or registers of facts relating to money. Every transaction involves a giver or seller and a receiver or purchaser, and necessitates an entry being made in the account which is increased and also in the account which is diminished. The application of this principle results in the method of *double entry*, which is suitable for every description of accounts, commercial or otherwise. In effect the receiver or purchaser is debtor to the giver or seller, and the giver or seller is creditor by the receiver or purchaser.

In the businesses dealt with in these volumes **the account settlements** would generally be what are known as either *prompt cash*, *monthly accounts*, or *quarterly accounts*. Prompt cash accounts are accounts where settlement is made against invoice, or against delivery of the goods in sound condition. Monthly accounts are those where credit is given, payment being made during the month following the delivery of the goods on any date in that period which may have been agreed upon between the seller and purchaser. Quarterly accounts are accounts where credit is given, and payment is due the day following the last day of the quarter

in which the goods were delivered. In the last case a few days' grace is customary to enable the account to be checked.

It should be borne in mind in bookkeeping that every item entered should be given its **reference or folio number**, so that each can be traced to its origin without difficulty.

It is essential to accuracy that all purchases and sales should pass to **ledger accounts.** Cash purchases should be as few as possible, and an adequate check should be arranged for cash sales. All accounts should be paid by cheque, and all cash received lodged in the bank daily, only the smallest items of daily expense being paid out of the petty cash. An amount would require to be drawn weekly from the bank to cover wages, salaries, and petty cash. The exact amount required for these services should be drawn by cheque and the amount of each service shown on the counterfoil, as each amount has to be entered to a separate account in the ledger.

Trading accounts are entered under one of two systems of bookkeeping, known as *single* and *double entry* respectively. The latter system, owing to its accuracy when properly carried out, is recognized as necessary for all businesses except those conducted on a very small scale. Specially prepared books of different sizes and qualities for either system are obtainable from every stationer.

The ordinary method of double-entry bookkeeping being adopted for the trading accounts, the following stock-pattern books are required: *Cash Book, Sales Day Book, Invoice Book, Sales Ledger, Bought Ledger, Private Ledger, Petty Cash Book,* and *Bill Book.* In addition to these the following books (which would probably require to be specially made) are necessary: *Order Book, Manifold Delivery Book, Manifold Ordering Book,* and *Receipt Book.* Generally speaking, the most convenient size of account books is foolscap of 250 folios.

The Cash Book is for keeping an account of the whole of the cash received and disbursed, together with discounts allowed and received, and to ascertain readily the amount of money in hand and at the bank. It should be ruled with columns for the date and for the folio, and with three money or cash columns. In the first cash column on the Dr. or left-hand side, the discounts allowed would be entered; in the second column the amount of cash received; and in the third column the total amounts of the cash paid into the bank. In the first cash column on the Cr. or right-hand side, the discounts received would be entered; the second column would be used only for cash payments made from cash received; and in the third column would be entered the amount of each cheque drawn.

The Cash Book should be balanced with the **Bank Pass Book** each month. The amounts in the third column of the Dr. and Cr. sides of the Cash Book will be found in the Bank Pass Book on the respective sides. In balancing with the Bank Pass Book at the end of the month, there may be a few cheques paid into the bank not cleared, and there may also be some cheques sent to creditors which have not been presented. In order to make the Bank Pass Book balance agree with the Cash Book balance, the amount of the Bank Pass Book balance is entered at the foot

of the Cash Book folio at the end of the month; the amount of the cheques not cleared is then added, and the amount of those not presented is deducted as follows:—

	£	s.	d.
Balance as per Bank Pass Book (obtained by deducting the Cr. side from the Dr. side)	261	7	4
Add Cheques not cleared	5	0	11
	266	8	3
Deduct Cheques not presented	9	19	6
Cash Book Balance	256	8	9

The Cash Book Balance is then carried forward to the next month's account.

The discount columns should be added up each month, and the totals journalized as explained later.

The Sales Day Book will contain a record of all goods sold on credit, including the name and address of the purchaser, particulars of the goods sold, the price sold at, and the total amount of the sale. This book is usually ruled with columns for the date and folio, and with double cash columns. The Day Book entries are made from the Delivery Book, and should correspond in detail with the invoice. These entries are subsequently posted to the Dr. side of the various customers' accounts in the Sold or Sales Ledger.

The Invoice Book, or Bought Day Book, will contain a record of all goods bought on credit, including the name and address of the firms from whom the goods have been purchased, particulars of the goods, the price at which they have been bought, and the total amount of the purchase. This book is usually ruled in a similar manner to the Sales Day Book. The Invoice Book entries are written up from the invoices received, after they have been checked. The entries are subsequently posted to the Cr. side of the various sellers' accounts in the Bought Ledger.

The Sales Ledger contains an account for every customer who purchases goods on credit. A convenient ruling is with columns for date and folio and double cash columns, these occupying one half of the page, the remaining portion being ruled similarly, so that Dr. and Cr. entries may be made on the same page. A thumb index is provided. No details of the goods bought by the customer are entered, as full particulars are in the Day Book. The entry from the Day Book is simply posted into the Sales Ledger on the Dr. side as "To goods", giving the amount and date of the sale. From this book is ascertained the amount of debtors' accounts outstanding. It is necessary when posting any item to a ledger that the book and folio from which the item was obtained be entered for facility of reference, and vice versa.

The Bought Ledger contains an account for every firm from whom a purchase is made on credit. The ruling is similar in every detail to that of the Sales Ledger. No details of goods purchased are entered in the

Bought Ledger, these being already contained in the Invoice Book, but the entry is posted from the Invoice Book to the Cr. side of the Bought Ledger as "By goods", giving the amount and the date of the purchase. From this book is ascertained the extent of the liabilities for purchases at any given date.

The Private Ledger contains accounts which are of a confidential nature, such as Capital, Profit and Loss Account, Partners' Drawing Accounts, Loans, Premises, &c. It also contains what are called *Impersonal Accounts*, such as Rent, Rates, and Taxes, Gas, Water, Salaries, Travelling Expenses, Bills Payable and Bills Receivable, Machinery and Tools, Discount and Interest, Carriages, Trade Expenses, and Bad Debts. This ledger would be accessible to the Principals, the Confidential Clerk, and the Accountant only. The Private Ledger is ruled in a similar manner to the other ledgers.

The Journal is an intermediary book for completing the system of double entry, and is used for making transfer entries. The ruling is usually (1) a column for the date, (2) a column for the folio, and (3) two cash columns. These cash columns represent respectively the Debtor and the Creditor sides of the Ledger. All impersonal items are usually passed through the Journal. As an example, if a bill of exchange is accepted, the account of the drawer would be charged and the Bills Payable account credited in the Impersonal Ledger; or in the case of a Bill Receivable being discounted, the entries would be journalized thus: debit Cash for the amount of cash received, and debit Discount Account for the amount charged for discounting the bill; credit Bills Receivable account with the full amount of the bill. The details of the bill so discounted would be stated at the foot of the entry in the Journal.

A Petty Cash Book is required to record all petty expenses or disbursements which are strictly cash transactions. The most convenient ruling for this book is several money columns on the Cr. side and one money column on the Dr. side. Cheques should be drawn for Petty Cash of (say) £5 value at a time, this amount being entered as a payment on the Cr. side of the Cash Book, and also entered on the Dr. side of the Petty Cash Book as a receipt. On the Cr. side of the Petty Cash Book is shown how the money is expended, the several money columns being utilized to facilitate analysis of the expenditure, the columns being totalled each month and posted to the various accounts in the Private Ledger. The Petty Cash Book should be balanced weekly, bringing down the balance of cash in hand. The analysis under headings allows the expenditure to be more easily appropriated, the petty cash being a frequent source of leakage in small amounts, which may tend to make a considerable difference to the profit. Such items as postage, carriage on goods, cartage, sundry travelling expenses, and even small tools, which should be charged to their respective sales or jobs, are likely to be overlooked in the lump sum, unless a careful watch is kept over the Petty Cash Book.

The Bill Book usually contains a record of bills receivable and bills payable, and is made with suitable ruling—one end for bills receivable, and the other for bills payable.

The Order Book is a book similar to those previously described, and specially ruled to meet the requirements of the business. In a general

ORDER BOOK

10

FEBRUARY, 1908

Date.	Order No.	Customer's Name.	Particulars of Order.	Date Completed.
17	66	Brown, James.........	72 sets 4″ copper ball spinnings 22· gauge.................	20/2/08

way suitable ruling would be columns for the date, the order number, the name of the customer, the subject matter of the order, and the date when completed.

The Delivery Book is a manifold book specially made and printed, so arranged that two detachable carbon copies are taken at the time the

DELIVERY BOOK

No. 160.

JOHNSON & Co.,

VULCAN WORKS,

LONDON,............................19...

M..

Received Goods as under:—

Signature......................................

original is written, one copy to be retained by the consignee, one copy for the consignee's signature, and the third and original remaining as a counterfoil in the delivery book for the use of the office. The printed matter should contain the name, address, and trade of the firm by whom the book is used, and also prominent positions for the date and customer's name. One of the carbon copies should be marked "Please Receive", and the other "Received", the latter having a space at the foot for the signature of the consignee or his agent. The delivery notes should be

numbered consecutively throughout the book, every series of three bearing the same number. The delivery book is required for the purpose of registering the despatch of all goods, notifying the consignee of the fact, and obtaining evidence of the receipt of the goods by the consignee or his agent.

The Ordering Book should be a manifold book, one carbon copy being made at the same time as the original is written. The forms should be

ORDERING BOOK

No. 1507.

VULCAN WORKS,

LONDON,.......................19...

M...

Please supply and forward to...

Carriage.....................   and oblige,

Marks........................   JOHNSON & Co.

N.B.—No goods are to be forwarded without an official order, and an invoice bearing the above number must accompany the goods.

specially ruled and numbered consecutively, and should have printed matter containing the name, address, and trade of the firm issuing the order, spaces for the date, the name of the firm to whom the order is issued, the destination of the goods, any marks under which the goods are to be consigned, and the means of transport. It is usual to include a footnote stating that "No goods are to be forwarded without an official order, and an invoice bearing the above number must accompany the goods".

Receipt Book, &c.—A special book is usually kept for official receipts, and other minor books of reference are sometimes required for office routine, such as for stamps, &c.

For a purchase an order form is made out in favour of the seller for the goods required. In due course the goods are received into the stores, and particulars are entered in the inward delivery book by the storekeeper, including particulars of the weight, number, and description, as may be necessary, the firm from whom the goods were received, and probably the means of transport, as it is advisable to know this in the event of there being any discrepancy or damage. These particulars are handed into the office at the end of the day by the storekeeper, and the clerk whose duty it is to check the invoice (which would already have been received notifying the despatch of the goods) examines and compares the two documents to ascertain that each item received is in accordance with that invoiced. To ensure that this is properly carried out, an indiarubber stamp should

be provided, with which all invoices would be impressed. The impression should leave spaces for the initials of the clerical staff responsible for checking the invoices, and so long as any of these spaces are incomplete, the invoices should not be filed.

INDIARUBBER STAMP FOR INVOICES RECEIVED

Rates checked by...........	....
Calculations checked by...	....
Quantities checked by......	....
Passed for payment by....	....
Appropriated to............	....
Invoice Book folio	....

After the rates, quantities, and calculations have been checked, the invoice is dealt with for appropriation, the items being entered at their net amount either upon the prime cost cards to the particular work for which the goods were ordered, or upon the stock cards, as the case may be. The invoice is then ready for entry into the Invoice Book, a fair copy being made, showing corrections (if any), and the folio of the Invoice Book being added to the invoice in the space provided in the impression before referred to. The invoice can then be filed or guarded for future reference.

It is now necessary to open an account in the Bought Ledger in favour of the seller or creditor, and this is carried out as follows. Dr. and Cr. are written in the top left- and right-hand corners of the page respectively, and the name of the firm is written in large hand at the head of the page selected, and also in the thumb index, the number of the folio being added in the latter for reference. The amount of space likely to be required for entries of goods, &c., purchased from this firm during (say) the succeeding twelve months should be estimated, and the necessary following pages reserved. The account is then ready to receive the entry of the transaction on the credit side, the folio number of the Invoice Book being inserted in the column provided in the ledger, and vice versa. A separate entry in the account should be made for packing cases and other debits for which a credit is to be allowed at settlement.

It is necessary to keep invoices a certain period for reference, and arrangements have to be made to facilitate this. Two methods are in general use, the better system requiring a filing cabinet, which is described on p. 353, and the other method being by means of guard books. The guard book is a large and strongly bound book with leaves ruled with double cash columns. The invoices are fixed into the book, generally monthly and in alphabetical order, so that all the invoices received in the month from each firm appear in the order of dating. The

total of each invoice, as well as the credits and the aggregate of the monthly trading with each firm, is entered in the cash column; and the aggregate total of all the purchases is entered at the end of each month.

It is advisable to affix the receipt showing the discharge of the account to the invoice to which it applies, or to the uppermost invoice of a series covered by it.

A sale transaction is dealt with as follows. An order is received from a purchaser. This must be entered in the Order Book, and, presuming that the goods ordered are stock articles, a copy of the order is forwarded to the storekeeper, who in due course advises the office that the goods are ready for despatch. Delivery notes in triplicate are then prepared in the manifold Delivery Book, the carbon copies being detached and handed to the storekeeper to accompany the goods, if delivered by the consigner's own servants. The consignee's receipt would be obtained on the "Received" note, and this would be returned to the office. If the goods are forwarded by another mode of transport, the signature of the receiving agent would be obtained, and a counterpart of the delivery note forwarded by post to the consignee as an advice of the despatch of the goods. At the time of preparing the delivery note the entry in the Order Book should be compared with the particulars of the goods furnished by the storekeeper, and if found to be correct, the entry should be cancelled with a dating stamp in the column provided.

The despatch entry in the Delivery Book is next entered into the Day Book by the invoice clerk, who also inserts the prices and enters the Day Book folio upon the counterfoil of the Delivery Book. He then makes a fair copy of the entry in the Day Book upon an invoice heading in bill form, completing the extension column in the Day Book, with which the total of the invoice will agree, the invoice being posted in due course to its proper destination. An account with the purchaser is opened in the Sales Ledger in a precisely similar manner to that described in the Bought Ledger. The Day Book folio is entered in the column provided in the Sales Ledger, and vice versa. A separate entry in the account must be made for packing-cases and other items for which a credit is to be allowed at settlement.

To complete these transactions of purchase and sale it is necessary to discharge the liability in the one case, and receive payment for the asset on the other. The cash book is the medium through which the entries are closed.

In the case of a purchase, if an ordinary monthly credit account has been arranged, a statement of the liability will be received immediately after the close of that month from the seller, as recorded in his ledger. On receipt of this document it should be impressed, as shown, by an indiarubber dating stamp provided for the purpose. It is then examined by the ledger clerk, and compared with the seller's account in the Bought Ledger. If it is correct, deductions are made for credits or discounts (if any), and it is initialled in the space provided, and passed for payment, a cheque being drawn and transmitted in discharge of it, and a receipt in

INDIARUBBER STAMP FOR STATEMENTS OF ACCOUNT

Date received................	....
Date passed for payment..	....
Passed for payment by....	....
Ledger folio	....

acknowledgment being received in due course. The responsible clerk enters the amount of the cheque and the date of payment on the credit side of the Cash Book from the counterfoil of the cheque. At the same time he adds the Cash Book folio to the counterfoil. The ledger clerk then enters to the debit side of the seller's account in the Bought Ledger the amount of the Cash Book entry, and balances the account with the amounts of any deductions for credits or discounts, the Ledger folio being entered in the column provided in the Cash Book, and vice versa, thus recording the complete transaction of purchase and payment.

In the case of the sale effected, a statement will be forwarded immediately after the close of the month to the purchaser, compiled from his account in the Sales Ledger. This statement will include any balance brought forward (either debit or credit) previous to the sale having been effected; the amount of the sale is added, and a total showing the sum due to the end of the previous month completes the document. In due course a cheque, or cheques, for this amount will be received from the debtor, and entered in the debit side of the Cash Book under the date received. The cheque is duly acknowledged on the official receipt form and paid into the banking account, and the ledger clerk credits the purchaser's account in the Sales Ledger with the amount received, entering the Cash Book folio in the column provided, and vice versa. Any discounts or allowances are separately shown, thus recording the complete transaction of sale and payment.

In the Sales Ledger an account should be opened for **sundry traders** with whom transactions are very limited in number, say from one to three or four items per annum; this account should be kept within the smallest limits. In the Bought Ledger a similar account should be opened for sundry creditors.

Impersonal Accounts, under the headings previously referred to, should be opened in the Private Ledger in a similar manner to the personal accounts opened in the Bought and Sales Ledgers. The entries referring to impersonal transactions are posted to the accounts to which they apply.

For the purpose of further explaining **the system of posting**, it has been assumed that the following transactions have taken place. Each item having been posted to its account, it will be observed that the twofold nature of the transfers has been strictly adhered to in the different books provided for the purpose.

The opening balances for the period under review are as follows, the difference between the Assets and the Liabilities being the Capital, £1102, 13*s.* 2*d.*:—

LIABILITIES	£	s.	d.	ASSETS	£	s.	d.
J. Brown & Co.	29	15	0	W. Brown	5	6	2
Rent due	25	0	0	T. Robinson & Sons ..	48	5	4
Bills Payable	200	0	0	Stock	950	0	0
Balance Capital	1102	13	2	Bills Receivable	100	0	0
				Cash	253	16	8
	1357	8	2		1357	8	2

LIST OF TRANSACTIONS

		£	s.	d.
Sold W. Brown	Plumber's Goods ...		11	10
Bought of J. Brown & Co. ...	Wrought-iron Pipe	3	17	0
Bought of L. Douglas	Kitchener	7	5	0
Sold T. Jones & Co.	H.-W. Apparatus ...	156	15	0
Received Cash from T. Jones & Co., and allowed them £7, 16*s.* 9*d.* discount		148	18	3
Paid Cash for Wages		56	0	0
Paid Cash for Petty Cash...		5	0	0
Sold John Oakes	Bath...	10	10	0
Sold T. Robinson & Sons	Electric Bells ...	1	13	0
Sold Smith & Co., Limited ...	Electric Light Plant	590	0	0
Bought of T. Harrison & Sons ...	Lead Pipe	10	10	0
Bought of J. Harvey	Wire	4	12	6
Bought of J. Robinson & Co. ...	Oak Chimneypiece	10	5	0
Bought of T. Sandford & Co. ...	Boiler	75	0	0
Sold Slide Bros.	Bolts, &c.		3	2
Received Cash from Slide Bros.			3	2
Paid Cash to J. Harvey, and was allowed 4*s.* 8*d.* discount ...		4	7	10
Received Cash, T. Robinson & Sons, and allowed them £2, 8*s.* 3*d.* discount		45	17	1
Paid for Fares from Petty Cash			1	6
Paid Cash to J. Freeman for Rent		25	0	0
Bought Bill Stamp from Petty Cash			4	0
Paid Cash for Wages		64	0	0
Received Cash, Smith & Co., Limited, on a/c		200	0	0
Paid Fares from Petty Cash				9
Paid Cash, J. Robinson & Co., and was allowed 10*s.* 3*d.* discount		9	14	9
Paid Cash on Bill payable due		200	0	0
Bought Stamps and Registered Letter from Petty Cash ...			10	3
Paid Cash, J. Brown & Co., and was allowed £1, 9*s.* 9*d.* discount		28	5	3
Received Cash, W. Brown, and allowed him 5*s.* 3*d.* discount ...		5	0	11
Paid Cash, T. Harrison & Sons, and was allowed 10*s.* 6*d.* discount		9	19	6
Paid Cash for Salaries		45	0	0
Drew Cash for Private Expenses...		50	0	0
Received Cash for Bill Receivable		100	0	0
Accepted Bill payable on T. Sandford & Co.		75	0	0
Drew Bill Receivable on Smith & Co., Limited, allowing them £14, 5*s.* discount		375	15	0

BILLS OF EXCHANGE RECEIVABLE

No.	When Received.	From whom Received.	By whom Drawn.	On whom Drawn.	To whom and where Payable.	Date.	Time.	Due.	£	S.	D.	How Disposed of.
1	Jan. 31.	Smith & Co., Ltd.	Ourselves.	Smith & Co., Ltd.	Ourselves.	Jan. 31.	6 Months.	July 3.	375	15	0	Discounted.

BILLS OF EXCHANGE PAYABLE

No.	By whom Drawn.	Place.	Where Payable.	Date.	Time.	When Accepted.	When Due.	£	S.	D.	To whom Paid
1	T. Sandford & Co.	London.	Oates Bank, London.	Jan. 28.	3 Months.	Jan. 31.	May 1.	75	0	0	

CASH BOOK

Dr. CASH.

Date	Particulars	Fo.	£	s.	d.	£	s.	d.	£	s.	d.
	To Bal. brought forward								253	16	8
	" Jones, T., & Co.	2	7	16	9	148	18	3			
	" Slide Bros.	6				0	3	2			
									149	1	5
	" Robinson, T., & Sons	4	2	8	3	45	17	1			
	" Smith & Co., Ltd...	5				200	0	0			
									245	17	1
	" Brown, W.	1	0	5	3	5	0	11			
									5	0	11
	" Bill Receivable	P.L. 5							100	0	0
		J. 1	10	10	3				753	16	1

CONTRA. *Cr.*

Date	Particulars	P. L.	£	s.	d.	£	s.	d.	£	s.	d.
	By Wages	8							56	0	0
	" Petty Cash	1							5	0	0
	" J. Harvey	4	0	4	8				4	7	10
	" Freeman, J., Rent..	P.L. 7							25	0	0
	" Wages	P.L. 8							64	0	0
	" Robinson, J., & Co.	5	0	10	3				9	14	9
	" Bill Payable	P.L 4							200	0	0
	" Brown, J., & Co. ...	1	1	9	9				28	5	3
	" Harrison & Sons.....	3	0	10	6				9	19	6
	" Salaries	P.L. 13							45	0	0
	" Drawings	P.L. 2							50	0	0
	" Balance								256	8	9
		J. 1	2	15	2				753	16	1

	£	s.	d.
Balance as per Pass Book	261	7	4
Add not cleared	5	0	11
	266	8	3
Less Cheque outstanding	9	19	6
	256	8	9

SALES DAY BOOK

Folios			£	s.	d.	£	s.	d.
1	Mr. W. Brown, London........					0	11	10
	4 $\frac{3}{4}''$ Main Ferrules...............	1/3	0	5	0			
	2 2″ Caps and Screws	1/	0	2	0			
	3 lb. Plumbers' Solder	10*d.*	0	2	6			
	1 $1\frac{1}{2}''$ 7-lb. Lead "S" Trap....		0	2	4			
2	Messrs. T. Jones & Co., Manchester........................					156	15	0
	Providing and fixing Domestic Hot-water Supply Apparatus to Baths, Sinks, &c., complete, as Contract dated 11/5/06		156	15	0			
3	Mr. John Oakes, London					10	10	0
	1 5′ 6″ Pure Porcelain Enamel Roll Edge Bath with 1″ nickel plated fittings, complete............................		10	10	0			
4	Messrs. T. Robinson & Sons, Liverpool.......................					1	13	0
	4 3″ best quality Electric Bells	3/	0	12	0			
	2 No. 1 Dry Batteries	3/	0	6	0			
	3 Coils 1/20 Bell Wire	5/	0	15	0			
5	Messrs. Smith & Co., Ltd., Leeds					590	0	0
	Wiring for 310 Electric Light Points in Steel Conduit, complete, as Estimate dated 10/4/06		590	0	0			
6	Messrs. Slide Bros., Halifax...					0	3	2
	4 $\frac{5}{8}'' \times 2\frac{1}{2}''$ Square Head Bolts and Nuts	2*d.*	0	0	8			
	4 2″ Square Washer Plates....	3*d.*	0	1	0			
	1 Sheet $\frac{1}{8}''$ Wrought-iron Plate, 6″ × 1′ 6″.......................		0	1	6			
						759	13	0

INVOICE BOOK

Folios 1

Folios			£	s.	d.	£	s.	d.
1	J. Brown & Co., Leeds					3	17	0
	1″ 100 ft. Galvanized Pipe		3	4	0			
	2 Round Elbows...........	2/3	0	4	6			
	4 Tees...	2/1½	0	8	6			
2	Mr. L. Douglas, London					7	5	0
	1 42″ Independent Kitchener, Oven and Boiler		7	5	0			
3	T. Harrison & Sons, London.................					10	10	0
	¾″ 100 ft. 5 lb. Lead Pipe......................		5	0	0			
	½″ 200 ft. 3 lb. Lead Pipe..........		5	10	0			
4	Mr. J. Harvey, Southampton................					4	12	6
	110 yd. 7/18 Rubber-covered Electric Cable		4	12	6			
5	J. Robinson & Co., London					10	5	0
	1 Oak Chimneypiece, complete, with Overmantel		10	5	0			
6	T. Sandford & Co., York......................					75	0	0
	1 7′ 6″ × 3′ 0″ Vertical Steam Boiler with Mountings..		75	0	0			
						111	9	6

PETTY CASH BOOK

1

Receipts.		£	s.	d.	Particulars.	Travelling. £	s.	d.	Sundry Expenses. £	s.	d.	Postages. £	s.	d.	£	s.	d	Total. £	s.	d.	Cr.
To Cash	1	5	0	0	By Fares to City	0	1	6										0	1	6	
					" Bill Stamp..				0	4	0							0	4	0	
					" Fares to Holborn	0	0	9										0	0	9	
					" Stamps, 1*d*..								10	0				0	10	0	
					" Registered Letter......							0	0	3				0	0	3	
					" Balance......													4	3	6	
		5	0	0		0	2	3	0	4	0	0	10	3				5	0	0	
						J. L., 9			J. L., 10			J. L., 11									
To Balance...		4	3	6																	

JOURNAL

			£	s.	d.	£	s.	d.
	T. Sandford & Co.............*Dr.*	B. L. 6	75	0	0			
	To Bills Payable...............	P. L. 4				75	0	0
	Bills Receivable..............*Dr.*	P. L. 4	375	15	0			
	To Smith & Co., Ltd.........	S. L. 5				375	15	0
	Discounts A/c................*Dr.*	P. L. 9	14	5	0			
	To Smith & Co., Ltd.........	S. L. 5				14	5	0
	(Being Discount allowed in their A/c)							
	Stock A/c.....................*Dr.*	P. L 6	111	9	6			
	To Sundry Persons...........					111	9	6
	(Being Purchases during Month.)							
	Sundry Persons..............*Dr.*		759	13	0			
	To Stock A/c..................	P. L. 6				759	13	0
	(Being Sales during Month.)							
	Discounts A/c................*Dr.*	P. L. 9	10	10	3			
	To Sundry Persons...........					10	10	3
	(Being Discounts allowed during Month.)							
	Sundry Persons..............*Dr.*		2	15	2			
	To Discounts A/c..............	P. L 9				2	15	2
	(Being Discounts received during Month.)							
	Capital A/c...................*Dr.*	P. L. 1	50	0	0			
	To Drawings...................	P. L. 2				50	0	0
	(Being Drawings for Month.)		1399	7	11	1399	7	11
	CLOSING ENTRIES							
	Stock A/c ....*Dr.*	P L 6	326	6	7			
	To Profit and Loss A/c	P. L. 3				326	6	7
	Profit and Loss A/c.........*Dr.*	P. L 3	212	16	7			
	To Rent, Rates, and Taxes...	P. L. 7				25	0	0
	" Wages A/c..................	8				120	0	0
	" Discounts A/c............	9				22	0	1
	" Travelling A/c............	10				0	2	3
	" Sundry Expenses A/c....	11				0	4	0
	" Postages A/c..............	12				0	10	3
	" Salaries A/c................	13				45	0	0
	Profit and Loss A/c ....*Dr.*	P. L. 3	113	10	0			
	To Capital A/c	1				113	10	0
			652	13	2	652	13	2

BOUGHT LEDGER

Dr. J. Brown & Co., Leeds *Cr.* 1

		£	s.	d.			£	s.	d.
To Cash	1	28	5	3	By Balance		29	15	0
" Discount	1	1	9	9	" Goods	1	3	17	0
" Balance		3	17	0					
		33	12	0			33	12	0
					By Balance		3	17	0

Dr. L. Douglas, London *Cr.* 2

		£	s.	d.			£	s.	d.
To Balance		7	5	0	By Goods	1	7	5	0
					By Balance		7	5	0

Dr. T. Harrison & Sons, London *Cr.* 3

		£	s.	d.			£	s.	d.
To Cash	1	9	19	6	By Goods	1	10	10	0
" Discount	1	0	10	6					
		10	10	0			10	10	0

Dr. J. Harvey, Southampton *Cr.* 4

		£	s.	d.			£	s.	d.
To Cash	1	4	7	10	By Goods	1	4	12	6
" Discount	1	0	4	8					
		4	12	6			4	12	6

Dr. J. Robinson & Co., London *Cr.* 5

		£	s.	d.			£	s.	d
To Cash	1	9	14	9	By Goods	1	10	5	0
" Discount		0	10	3					
		10	5	0			10	5	0

Dr. T. Sandford & Co., York *Cr.* 6

		£	s.	d.			£	s.	d.
To Bill	J. 1	75	0	0	By Goods	1	75	0	0

SALES LEDGER

Dr. W. BROWN, LONDON *Cr.* 1

		£	s.	d.			£	s.	d.
To Balance		5	6	2	By Cash	1	5	0	11
" Goods	1	0	11	10	" Discount	1	0	5	3
					" Balance		0	11	10
		5	18	0			5	18	0
To Balance		0	11	10					

Dr. T. JONES & CO., MANCHESTER *Cr.* 2

		£	s.	d.			£	s.	d.
To Goods	1	156	15	0	By Cash	1	148	18	3
					" Discount	1	7	16	9
		156	15	0			156	15	0

Dr. JOHN OAKES, LONDON *Cr.* 3

		£	s.	d.			£	s.	d.
To Goods	1	10	10	0	By Balance		10	10	0
To Balance		10	10	0					

Dr. T. ROBINSON & SONS, LIVERPOOL *Cr.* 4

		£	s.	d.			£	s.	d.
To Balance		48	5	4	By Cash	1	45	17	1
" Goods	1	1	13	0	" Discount	1	2	8	3
					" Balance		1	13	0
		49	18	4			49	18	4
To Balance		1	13	0					

Dr. SMITH & CO., LIMITED, LEEDS *Cr.* 5

		£	s.	d.			£	s.	d.
To Goods	1	590	0	0	By Cash	1	200	0	0
					" Bill Receivable .	J. 1	375	15	0
					" Discount	"	14	5	0
		590	0	0			590	0	0

Dr. SLIDE BROS., HALIFAX *Cr.* 6

		£	s.	d.			£	s.	d.
To Goods	1	0	3	2	By Cash	1	0	3	2

PRIVATE LEDGER

Dr. CAPITAL A/c *Cr.* 1

		£	s.	d.		P.L.	£	s.	d.
To Drawing	J. 2	50	0	0	By Balance		1102	13	2
" Balance		1166	3	2	" Profit and Loss .	3	113	10	0
		1216	3	2			1216	3	2
					By Balance		1166	3	2

Dr. DRAWINGS A/c *Cr.* 2

		£	s.	d.			£	s.	d.
To Cash	1	50	0	0	By Capital A/c	J. 2	50	0	0

Dr. PROFIT AND LOSS A/c *Cr.* 3

	J. L.	£	s.	d.		J. L.	£	s.	d.
To Wages		120	0	0	By Bal. Trading A/c	5	326	6	7
" Salaries...........	3	45	0	0					
" Rent...............	"	25	0	0					
" Discounts.........	"	22	0	1					
" Postages	"	0	10	3					
" Sundry Exes. ...	"	0	4	0					
" Travelling	"	0	2	3					
" Balance net profit		113	10	0					
		326	6	7			326	6	7

Dr. BILLS PAYABLE *Cr.* 4

	C. B.	£	s.	d.			£	s.	d.
To Cash	1	200	0	0	By Balance		200	0	0
" Balance		75	0	0	" Sandford & Co. .	J. 1	75	0	0
		275	0	0			275	0	0
					By Balance		75	0	0

Dr. BILLS RECEIVABLE *Cr.* 5

		£	s.	d.		C. B.	£	s.	d.
To Balance		100	0	0	By Cash	1	100	0	0
" Smith & Co., Ltd.	J. 1	375	15	0	" Balance		375	15	0
		475	15	0			475	15	0
To Balance		375	15	0					

Dr. STOCK A/C *Cr.* 6

		£	s.	d.			£	s.	d.
To Balance Stock...		950	0	0	By Sales	J. 1	759	13	0
" Purchases.........	J. 1	111	9	6	" Stock............		628	3	1
" Profit and Loss .	P. L. 3	326	6	7					
		1387	16	1			1387	16	1
To Stock		628	3	1					

Dr. RENT, RATES, AND TAXES *Cr.* 7

		£	s.	d.		P. L.	£	s.	d.
To Cash	1	25	0	0	By Balance		25	0	0
" Amount due		25	0	0	" Profit and Loss .	3	25	0	0
		50	0	0			50	0	0
					By Balance		25	0	0

Dr. WAGES *Cr.* 8

	C. B.	£	s.	d.		P. L.	£	s.	d.
To Cash	1	56	0	0	By Profit and Loss .	3	120	0	0
" Cash	1	64	0	0					
		120	0	0			120	0	0

Dr. DISCOUNTS *Cr.* 9

		£	s.	d.			£	s.	d.
To Smith & Co.	J. 1	14	5	0	By Sundries	J. 1	2	15	2
" Sundries		10	10	3	" Profit and Loss .	P. L. 3	22	0	1
		24	15	3			24	15	3

Dr. TRAVELLING *Cr.* 10

	P.C.B.	£	s.	d.		P. L.	£	s.	d.
To Cash	1	0	2	3	By Profit and Loss .	3	0	2	3

Dr. SUNDRY EXPENSES *Cr.* 11

	P.C.B.	£	s.	d.		P. L.	£	s.	d.
To Cash	1	0	4	0	By Profit and Loss .	3	0	4	0

Dr. POSTAGES *Cr.* 12

	P C.B.	£	s.	d.		P. L.	£	s.	d.
To Cash	1	0	10	3	By Profit and Loss .	3	0	10	3

Dr. SALARIES *Cr.* 13

			£	s.	d.		P. L.	£	s.	d.
	To Cash	1	45	0	0	By Profit and Loss .	3	45	0	0

Stocktaking.—For the purpose of ascertaining whether a business is being carried on profitably, and also to arrive at the true financial position of the undertaking, it is necessary to take stock at the end of the financial year, the date coinciding with that upon which the accounts in the ledger are made up. The periods are usually of either six or twelve months' duration. It is usual to rate all goods at their net cost price, no sale having been effected. This opportunity should be taken of disposing of obsolete stores, as these augment the working expenses by employing capital to no profitable purpose, besides incurring expense in handling and occupying valuable space. Partly finished work, whether indoor or outdoor, should be valued at the net cost of the labour and material plus the working expenses. In valuing plant and machinery, the first cost value may be taken and reduced each year, the annual reduction being a fixed percentage of the value at the beginning of the year, the percentage varying in inverse proportion to their life as profitable tools. Too much care and consideration cannot be given to the valuation of the stock, fixtures, plant, and premises, as to undervalue or overvalue them produces an unreliable and misleading statement of affairs.

Having carefully gone through the various postings, it will now be necessary to prepare the Profit and Loss Account and Balance Sheet; but before doing so a **Trial Balance** (as shown on next page) for the purpose of checking the arithmetical accuracy of the entries is necessary. All the Dr. and Cr. balances are abstracted from the Ledger. As for every transaction a Dr. entry has its corresponding Cr. entry, the totals of the Dr. and Cr. sides of the trial balance must agree. Should there be any difference, it will be necessary to check each of the items individually, until the error is discovered.

Closing of Accounts.—Having proved the arithmetical accuracy of the accounts by the Trial Balance, the next step is to close the Stock Account, the Discount Account, and the various Expenses Accounts in the Private Ledger. These entries are what are called **adjusting entries.** By a careful perusal of the Journal on page 340, it will be seen how the closing of these accounts is effected. There now remain in the Private Ledger the Profit and Loss Account, the Partners' Private Account, and the Capital Account to close. Having carried the gross profit from the Stock Account and all balances of the Expense Accounts to the Profit and Loss Account, it now becomes necessary to close this account and so ascertain the net profit or loss. The entries on the debtor and creditor sides are added up, and the difference between these totals represents the net profit or loss for the year. If the credit side is the greater a profit has been made, but if the debtor side is the greater a loss has been sustained. In the example given above,

a net profit of £113, 10*s*. has been made. The Profit and Loss Account is then closed by debiting it with this amount and crediting Capital Account. (See Closing Entries in Journal, page 340.) The net result of the Trading for the year has been an increase in the Partners' Capital by £113, 10*s*. From this, however, must be deducted the amount of the Partners' private drawings, amounting to £50. This Partners' Private Drawing Account is closed by debiting the Capital Account with the £50 and crediting the Private Account. The final account to close in the Private Ledger is the Capital Account. Adding up the debtor and creditor sides, we find the difference to be £1166, 3*s*. 2*d*., which is the new Capital.

Closing of the Personal Accounts.—To close the accounts in the Bought and Sales Ledgers is a very simple matter. All that is required to be done is to add up the debtor and creditor sides, and if they agree rule them off as closed. If they do not agree, then there is a balance. The amount of this balance is entered on the lesser side, and the account added up and ruled off. Care must be taken, however, to bring this balance forward to the next year. Balances are called either debtor or creditor balances, as the case may be.

TRIAL BALANCE

		£	s.	d.	£	s.	d.
1.	Capital				1102	13	2
2.	Drawings	50	0	0			
4.	Bills Payable				75	0	0
5.	Bills Receivable	375	15	0			
6.	Stock A/c: General Profit ...				326	6	7
	Stock	628	3	1			
7.	Rent, Rates, and Taxes; Profit and Loss	25	0	0			
	" Due				25	0	0
8.	Wages	120	0	0			
9.	Discounts	22	0	1			
10.	Travelling	0	2	3			
11.	Sundry Expenses	0	4	0			
12.	Postages	0	10	3			
13.	Salaries	45	0	0			
As per List.	Debtors	12	14	10			
	Creditors				11	2	0
C. B., 1.	Cash at Bank	256	8	9			
P. C. B., 1.	Petty Cash in Hand	4	3	6			
		1540	1	9	1540	1	9

Balance Sheet.—Having ascertained from the Trial Balance that the postings in the books are correct, all adjustments completed, and all accounts balanced, the Balance Sheet can be prepared. A Balance Sheet is a statement showing upon one side the assets, or what the business possesses or is entitled to receive, and upon the other side the liabilities, or what the business owes.

BALANCE SHEET

As at.....................................19

Liabilities.	£	s.	d.	£	s.	d.	Assets.	£	s.	d.
Capital	1102	13	2				Stock	628	3	1
Add Profit.....	113	10	0				Sundry Debtors..........	12	14	10
							Bills Receivable.........	375	15	0
	1216	3	2				Cash at Bank.............	256	8	9
Less Drawings	50	0	0				Petty Cash in Hand....	4	3	6
				1166	3	2				
Sundry Creditors...............				11	2	0				
Rent Due				25	0	0				
Bills Payable.....................				75	0	0				
				1277	5	2		1277	5	2

Auditor.—It is most necessary that a qualified accountant be employed to audit the accounts, and to prepare the Profit and Loss Account and Balance Sheet. The expense is small in comparison with the advantages gained, errors and irregularities often being brought to notice which would otherwise have escaped attention. A careful audit is the greatest safeguard against negligent bookkeeping and fraud, and brings to notice most useful data in concise form which are not otherwise obtainable.

CHAPTER III

PRIME COST KEEPING

Advantages.—It is seldom that work of the description dealt with in this article is undertaken without an estimate of the cost having been presented, in competition or otherwise. Although there are many factors to which the large variations in the tenders for a certain work may be attributed, a defective system of prime cost keeping may without doubt be claimed as one of them. In any case, a defective prime cost system is to the disadvantage of the engineer, as he may either price his work upon too high a basis, and as a consequence be unsuccessful in tendering, or upon the other hand he may price it too low and the work may prove unprofitable, with the result that he finds his financial resources seriously impaired. Too much care cannot be given to this department of the business, so that the actual cost of every article or section of the work may be given.

All work undertaken ought, where practicable, to be divided into sections, and the cost of material and labour to be expended upon each section should be fixed to conform with the prices allowed when estimating. It is most important that arrangements should be made in the execution of the work to ensure that these prices are not exceeded either in labour or

material. It is possible to ensure this with a carefully planned system thoroughly carried out. Such a system is of the greatest use in keeping the cost down to the lowest basis, and in furnishing accurate data for compiling future estimates.

The value of material for each section of the work having been ascertained from the estimate, care is required in issuing orders to stores and other channels to ensure that only the quantities allowed for are issued for the work. Particular attention should be paid to the return of any surplus stores or waste, for which credit should be given by the storekeeper in the stores inward delivery book. As the materials used consist principally of metals, the prices of which fluctuate considerably,[1] a close surveillance should be kept on the current market prices in order to obtain the utmost advantage in purchasing when prices are favourable. Great advantage is obtained by keeping the cost of different classes of material under separate heads, as this facilitates analysis and comparison with estimated costs.

For keeping the prime cost of materials for work in hand, there is no better method than **the card system**, which is adaptable to meet any requirements. The Materials Cost Card should be ruled on both sides,

MATERIALS COST CARD

										Credit.		
Date.		Cwt.	Qr.	Lb.	Oz.	Rate.	£	s.	d.	£	s.	d.

the work number and description of the job being distinctly written in the space provided at the head. The stores outward sheets are abstracted, entered upon the cards, and priced net in the extension or cash columns, and any credits from the stores inward sheets are similarly dealt with. Should the job be away from the works and the material be forwarded direct from the manufacturers, it would be entered upon the same card from the invoice, the card number being entered in the space provided for appropriation in each case. In the event of the space on the obverse of the card being insufficient, a total is made and carried forward to the reverse, and if further space is required, another card is attached to the first with a suitable clip. Immediately the job is completed, and the card or cards totalled, they are transferred to the file drawer for completed jobs. It is obvious that these cards record the net cost of the

[1] For charts showing the yearly and monthly fluctuations in the prices of tin, copper, zinc, and lead, see Plates XLVII and XLVIII.

whole of the material utilized upon the particular job to which the cards refer.

Wages.—Where a number of hands are employed, the question of wages is one of the most important, if not the most important item, involving a large amount of clerical work which requires to be executed with promptness, precision, and accuracy. Not only is it necessary that the employees should be paid punctually, but the cost of labour on any work should be available immediately the work is completed, or, if the work is incomplete, to the end of the previous day.

One of the best systems to attain this end is provided by the use of **daily time sheets.** In the case of men employed within the works, these

DAILY TIME SHEET

Name.................................. *No*................ *Date*..............................

Work No.	Particulars of Job.	Time Started on Job To-day.	Time Left Off.	Job Finished or not.	Total Hours (not to be filled up).	Signature.

Checked by................................*Foreman.*

are issued by the timekeeper each morning, and are returned to him completed by the employees as they leave the works at the end of the day, each sheet having been checked and initialled by the foreman. After verifying the times booked and the total number of hours on the sheet, the timekeeper would hand the sheets into the office to be dealt with by the time cost clerk. In the case of men employed outside the works, the daily time sheets would be handed to the men by the foreman, who would also return them to the office by post each day after checking and initialling them.

The time would next be entered from the daily time sheets to the **weekly wages sheets,** one of these being allocated to each man, his name, number, and rate being inserted in spaces provided at the head. The wages sheet, on which would be booked each day the full record of the previous day's work, would give particulars of the work upon which the man was engaged, and also the number of hours. With the ruling shown above, column 1 would be utilized for the work number, column 2 for a brief description of the work, six columns for the number of hours engaged upon the work (one column being for each day of the week), another

WEEKLY WAGES SHEET

No.................. *Name*....................................... *Rate*.................

Work No.	Description.	Fri.	Sat.	Mon.	Tues.	Wed.	Thurs.	Total Hours.	£	s.	d.	Week Ending.

column for the total number of hours engaged that week upon each job, cash columns for the amount of wages due, and a column for the date of the last day of the week to which the wages are made up. Each entry would be made from the daily time sheet, one line being allotted to each job, so that if the employee was engaged several days upon one job, his labour for those days would be entered upon one line and in the columns set out for those particular days. Any number of jobs could then be booked in one week, each showing a separate weekly total in the column provided.

To obtain **the prime cost of labour** expended upon each particular job, it is necessary to abstract the weekly wages sheets of all the men employed upon the job. The card system is one of the best means of effecting this purpose. The Time Cost Card should be of a different colour from the Materials Cost Card, and should be ruled as shown, obverse and reverse,

TIME COST CARD

Work No..........

		Date............				Date............				Date............				Date............			
No.	Name.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.	Hours.	£	s.	d.

the number and description of the job being distinctly written in the space provided at the head. The entries should be transferred from the weekly

wages sheets, the number and name of each employee engaged upon the job to which the card refers being entered in the first two columns, the total number of hours engaged in the third column, and the total cost of the labour in the first cash columns. After the whole of the entries on the weekly wages sheets have been transferred to the time cost cards, the hours and cash columns should be totalled. The totals comprise the number of hours of direct labour and wages expended upon the job during the previous week.

In the remaining columns should be entered the time and wages expended during the following weeks upon the same job. Four sets of time and cash columns on the obverse of the card will usually be sufficient. If the job should occupy a longer period, the reverse of the card would be utilized for the following four weeks, the total being brought forward from the obverse to the reverse. If necessary, additional cards can be attached to the first with a suitable clip.

Immediately the job is completed, and the card or cards totalled, they are transferred to the file drawer for completed cards, and attached to the materials cost card or cards bearing the same number, thus completing an accurate record of the actual expenditure in material and direct labour for that particular job.

Having obtained the direct costs chargeable to the work carried out, it is necessary to obtain the **indirect costs**. For this purpose, and in order to arrive at the actual prime cost, a careful analysis of the indirect costs should be made, and the work carried out by each department should be charged with that proportion of the indirect costs known as *Departmental Expenses*, which that department incurs, in addition to its proportion of the general expenses. The necessity for this will be seen if the matter is considered for a moment. In the case of work carried on in the workshops, using power, light, and possibly more expensive tools and machines than would be required for work undertaken outside the works, the former would require to be charged with considerably more indirect costs than the latter.

To obtain the fair proportion chargeable to each department, the different items of indirect expenditure should be considered separately, such as—

1. Rent, rates, and taxes.
2. Lighting.
3. Power.
4. Depreciation (stock and machinery).
5. Interest on capital.
6. Insurance (fire and workmen's compensation).
7. Show-room attendant, storekeepers, stores, &c.
8. General expenses, such as office or staff salaries, timekeeper, cartage, stationery, telephone, petty cash, repairs to buildings, &c.
9. Foreman's wages, non-productive labour in workshops.

Stores and Offices.—In computing the expenses incurred by the stores under heading 7, and by the office under heading 8, it is necessary to charge each with a proportionate amount of the rent, rates, taxes, lighting,

depreciation, interest on capital, and insurance, the totals obtained being afterwards charged to the productive departments.

To compute the amount of **departmental expenses**—viz., foreman's wages and indirect labour chargeable in the workshops—it will be necessary to abstract and separate the direct and indirect time and wages from the weekly wages sheets of the employees in that department. A special sheet is usually provided for this purpose, ruled as shown. The employee's name, and the number of hours engaged upon, and the amount of wages paid for, labour which is directly chargeable to jobs, would be entered upon one side of the special sheet. The name, and the number of hours engaged upon, and the amount of wages paid for, labour which is

SHEET FOR PRODUCTIVE AND INDIRECT LABOUR

		Productive.					Indirect.			
No.	Name.	Hours.	£	s.	d.		Hours.	£	s.	d.

chargeable to indirect labour, supervision, &c., would be entered upon the other side. These columns would be totalled, the totals representing the actual number of hours employed in direct labour which have already been entered upon the time cost cards to their respective jobs, and the total amount paid for the indirect labour incurred which has not been so charged.

To ascertain the proportion of indirect labour chargeable to each job, the total amount of indirect labour should be divided by the total number of hours for labour directly chargeable. This will give the hourly unit of expense for indirect labour chargeable to every hour of direct labour booked during the weekly period taken. For example, if the aggregate of the weekly expenditure for productive labour amounted to 500 hours, and the indirect labour for the same period amounted to £2, 1*s.* 8*d.*, the unit would be 1*d.* per hour, and this amount would be added to each productive hour booked upon the time cost cards.

In the factory taken as an example in this article, the productive departments would be as follows:—A, Show Room; B, Workshops; and C, Outside Work. The sales and work undertaken by these departments will be required to bear the amount of the indirect expenditure arranged

under the sub-heads 1 to 9 (p. 351), the amount under each sub-head being charged wholly or in part to each department.

The proportion of the general expenses chargeable to the different productive departments varies, of course, in different businesses. In the case of Department A, it would be charged as a percentage value calculated upon the net cost of the goods sold for the year. In the case of Department B, it would be necessary to reduce the chargeable amount to the hour units, as in the case of indirect labour. In the case of Department C, the chargeable amount would be reduced to a percentage value calculated upon the net cost of the labour and material utilized throughout the year.

The indirect cost values for each department having thus been obtained, it is only necessary to add them to the prime costs of material, or of labour and material, as the case may be, and the result will be figures representing the prime cost of the article or work undertaken.

Where heavy or expensive machines are employed for certain work, it will be necessary to make special allowances in pricing to cover the extraordinary expenses incurred.

CHAPTER IV

THE OFFICE

In no department of a works is it more necessary to have **a properly organized system** than in the office, as this is the centre from which all the other departments are directed, and should it be defective, the efficiency of the departments depending upon it will be greatly impaired. Not only has the conduct of the departments inside the works to be controlled by the office, but also the commercial section, relating to all extraneous negotiations.

It is necessary in the conduct of any business to record in writing all transactions that take place, and arrangements must be made to enable the documents of various kinds to be dealt with promptly, applied to their particular purpose, and stored in such a manner as to facilitate easy reference. To effect this purpose economically, up-to-date offices are provided with systems of books and files in addition to the usual furniture. Of late years filing cabinets and card systems have been introduced, and are now considered indispensable. Besides these it is necessary to provide machines for writing, copying, and calculating, which are too well known to require description.

Filing cabinets, of which there are several designs, are arranged to file documents, such as correspondence, invoices, orders, &c., in such a manner as to be easy of reference. The systems most generally adopted are what are known as *flat* and *vertical* filing, the former being considered preferable where the majority of the documents to be filed consist of single papers, and the latter where many documents referring one to another are

filed together. The cabinets usually comprise one or more files or drawers, as the case may be, each file being subdivided either alphabetically, numerically, or to meet specific requirements. Cabinet filing systems are of the greatest use in filing correspondence, invoices, and other documents which may be required for reference, and can be easily adapted to meet special requirements.

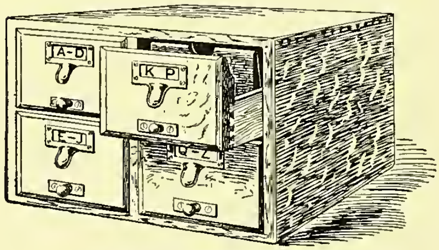


Fig. 1065.—Card Index Cabinet

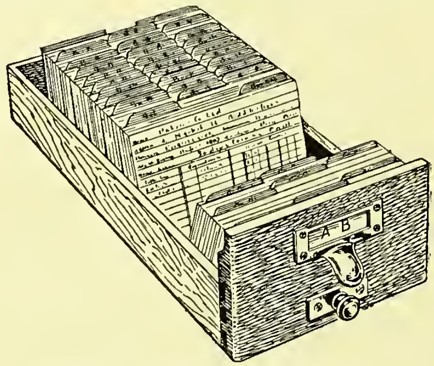


Fig. 1066.—Drawer of Card Index Cabinet

The card index file (fig. 1065) consists of a cabinet containing one or more drawers (fig. 1066), each of which is furnished with a number of cards, specially ruled for the purpose for which they are to be utilized. Guide cards alphabetically or numerically labelled are placed between the other cards to facilitate the location and withdrawal of any particular card. The card system has been mentioned as being specially suitable for keeping the prime costs of material, labour, and stock.

In the **flat filing system** (fig. 1067) the number of files (fig. 1068) required in the cabinet will depend upon the number of documents to be dealt with daily, and should be about thirty where sixty papers per diem have to be filed. The number of files apportioned to each particular series of documents, which may be either the series of correspondence, invoices, orders, or petty cash receipts, &c., must be proportionate to the number of each of these papers received daily.

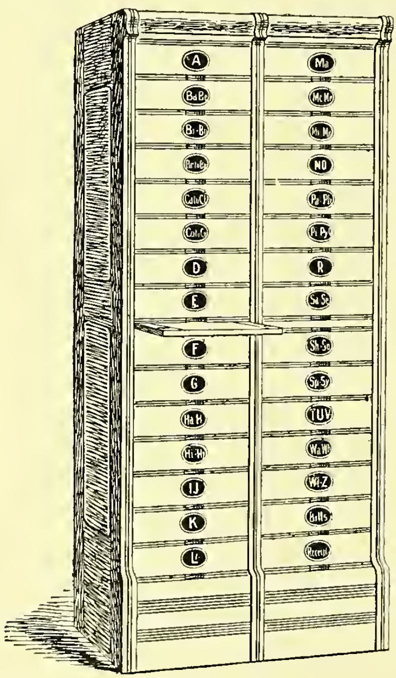


Fig. 1067.—Flat Filing Cabinet

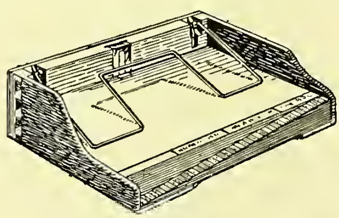


Fig. 1068.—Drawer of Flat Filing Cabinet

A single file (fig. 1068) consists of a tray fitted with a removable thumb index, which is generally alphabetically arranged either in the simple alphabet or in combinations of letters, and can be obtained, prepared from most careful investigation by the makers, to meet practically any requirements. The documents to be filed are placed between the leaves of the index, without fixing in any way, the first letter or combination of letters of the name of the firm from whom the document was received corresponding with the letter or letters of the index. If two or more files are necessary to contain the documents, the index would be amplified and run through the series, commencing at the letter A in the first file, and finishing at the letter Z in the last. The contents of each file and the section of the index should be legibly recorded on the front of each file, as, for example:—

ESTIMATES

G—K er

The vertical filing cabinet (fig. 1069) contains one or more drawers of sufficient width and depth to take the documents required to be filed without folding. For the purpose of general business correspondence, invoices, orders, &c., drawers taking foolscap papers are suitable. In the cabinets of standard size, sufficient space is provided in each drawer for filing about 5000 papers. Each drawer is provided with folders or covers, in which the documents are placed, each correspondent being allotted a number upon the first transaction, and all future correspondence being conducted under this reference number. A folder under the same number would be allotted in the drawer to the correspondent, and in this folder all his documents would be placed.

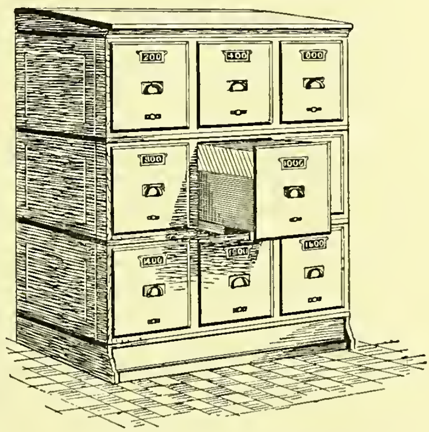


Fig. 1069.—Vertical Filing Cabinet

In a case where an undertaking is being carried out in which much **correspondence** is likely to arise, possibly with various firms, and it is desirable to bring it all together, this particular work would be allotted a number and folder, and all correspondence in connection with that work would be conducted under that number and consequently filed in the one folder. It is sometimes convenient to subdivide the correspondence in connection with a job into sections, either to particular firms or to parts of the work, so that the whole of the correspondence relating to a particular part or firm is available for immediate reference. This is provided for by having several folders under the one number; each folder, in addition to bearing the general reference number, would bear the name of the firm or section of the work, as the case may be.

It is necessary to provide an alphabetical index to the folders, arranged

under the card system (fig. 1065), to facilitate reference to the number under which the documents relating to the firm or work are filed. In some instances it may be more suitable to the requirements to utilize the alphabetical in preference to the numerical index upon the folders.

It will be found advantageous to attach the carbon or press copies of replies to correspondence, and file them with the letters or subject matters to which they refer, so that a consecutive record of the transaction is contained in one folder. Telephone messages should be written on special slips with the date and hour of receipt inserted, and should be filed with the correspondence, and all telegrams received and carbon copies of all telegrams sent should also be filed.

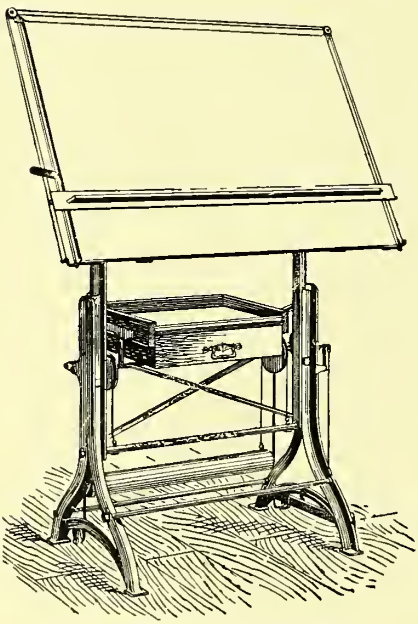


Fig. 1070.—Standard Drafting Table

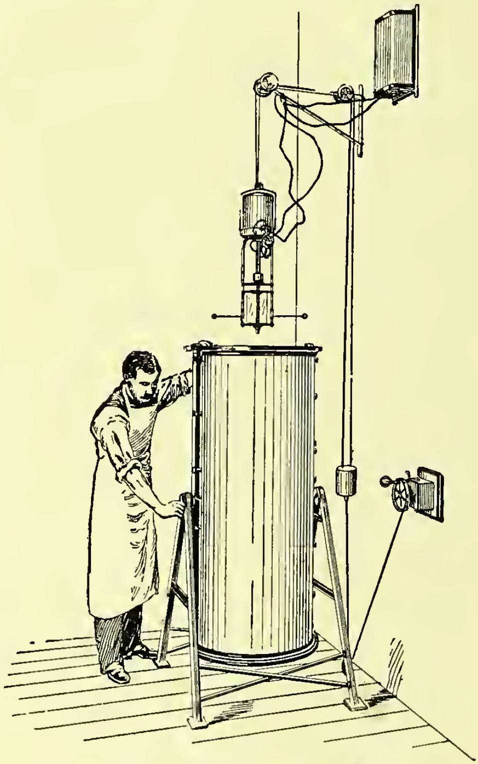
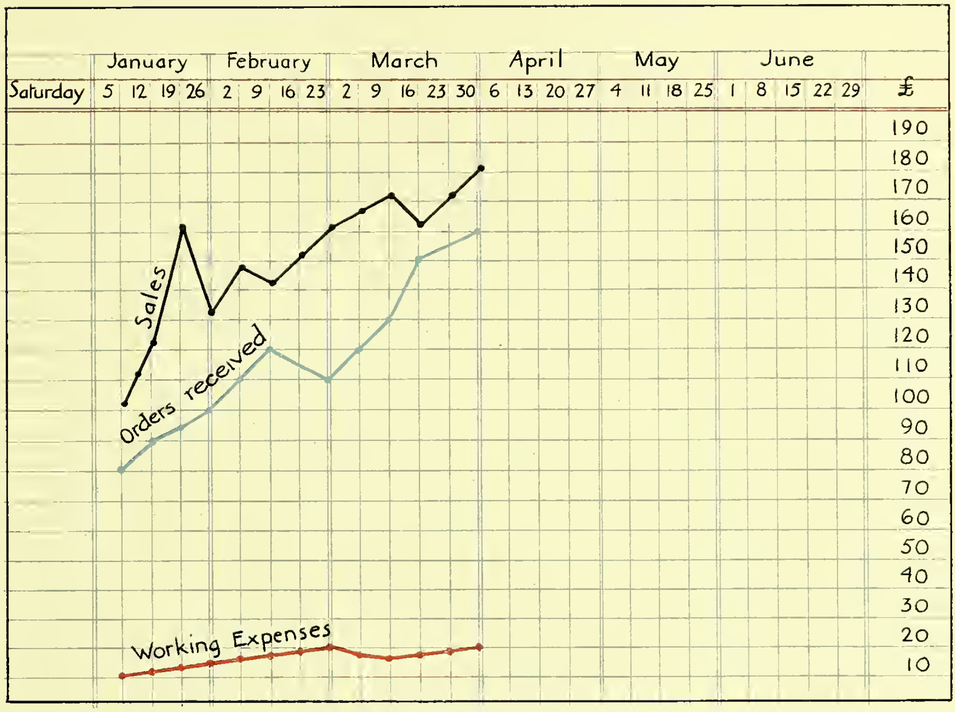


Fig. 1071.—Electric Photo-copying Machine

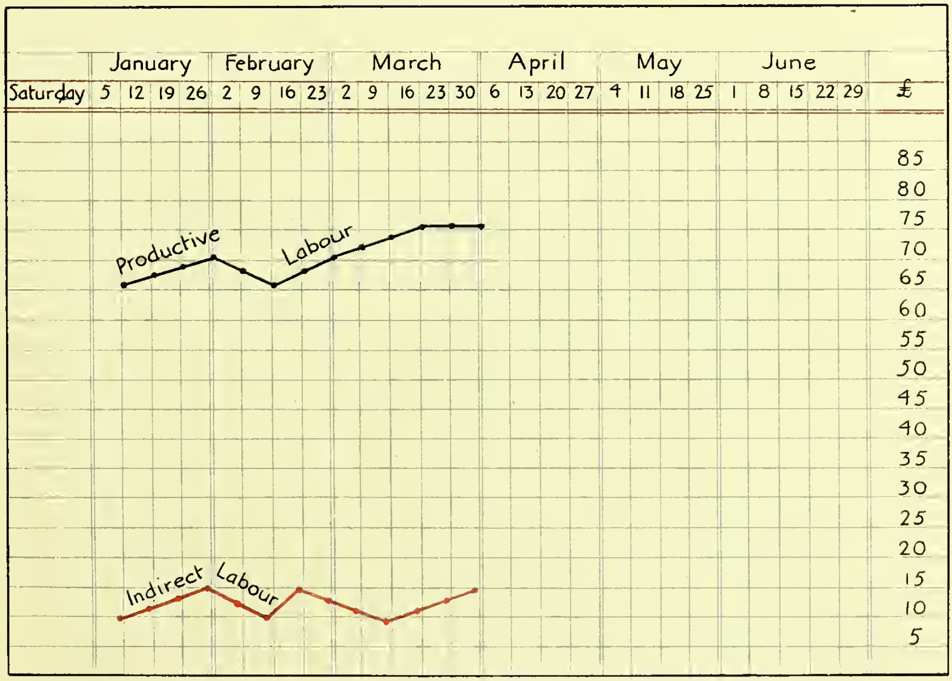
Next to the manager's office, **the drawing office** may be considered the most important department in a works. The furniture usually consists of a drawing table, cabinet to contain drawings, apparatus for producing black on white, and blue, prints, and the larger instruments which are not provided by the draughtsman.

Halden & Co.'s **Standard drafting table** (fig. 1070) is a great improvement upon the ordinary table or desk, as it is adjustable in height, and can be readily set to any angle required by a draughtsman.

An electric photo-copying machine (fig. 1071), from which photo prints in blue, or black on white, can be obtained in a very short time, occupies little space, and is made in several sizes, suitable to the requirements of almost any drawing office.



No. 1. SCALES, ORDERS, AND EXPENSES



No. 2. LABOUR

BUSINESS CHARTS

An adjustable set square, the Simplon (fig. 1072), is a very useful instrument, enabling angular lines to be quickly made without tilting the T-square.

The rotary calculator known as "The Calculex" (fig. 1073) is a combination of the slide rule and pocket calculator, and embodies all the advantages of the slide rule, giving great accuracy and continuous readings, and is convenient to carry in the pocket.

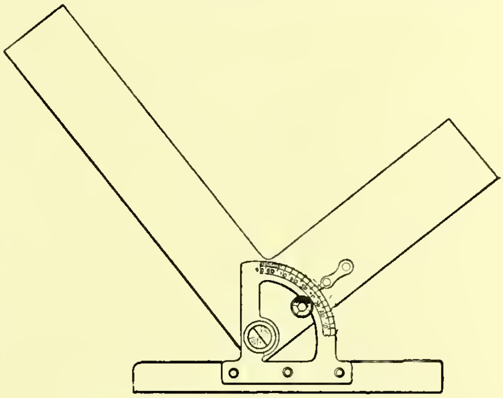


Fig. 1072.—The Simplon Adjustable Set Square

The work of the drawing office may be divided into two sections, the first being the preparation of the designs and of the quantities for estimating, and the second the preparation of the working drawings, and of full lists of materials required to enable the other departments to execute the work. The manager ought to give definite instructions in writing to the chief draughtsman relative to the work required, and it is of vital importance that the working drawings should give full and exact details of the work required of the different departments, so that it will not be necessary for the foreman to have further reference to the management after receiving the material and drawings.

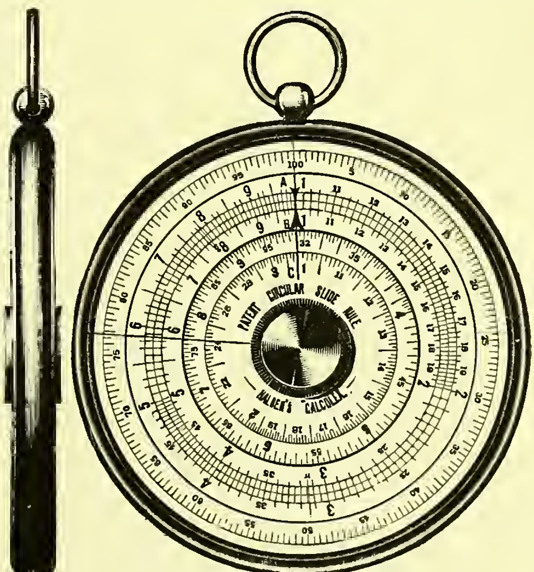


Fig. 1073.—The Halden Calculex

All drawings should be numbered, and a full record of them should be kept in a book provided for that purpose in the drawing office, so that they can be easily referred to in the case of repeat orders, alterations, or repairs.

Subdivision of Work.—To facilitate cost-keeping, and in order to carry out work expeditiously, it is necessary to divide it into sections, each section as far as possible to be a completed part of the whole. To arrive at this end, each section is given a work number, by which it is distinguished in every department, and all departmental reference to each of the sections should be made under the work number. The work numbers are applied to the different sections of work in the drawing

office, and are entered by the draughtsmen upon the detail drawings, and also upon the orders to the foremen and storekeeper, who should see that all time and material expended on those sections are entered to their respective work numbers upon the daily time sheets and stores outward delivery sheets. The numbers are entered in rotation in a work number book kept specially for the purpose, from which they are entered by the prime cost clerk upon the time cost cards and material cost cards.

The lists of materials required for each section of the work having been prepared in the drawing office, a copy should be issued to each department engaged upon the section, so that each department may know the material that is in hand for that section. The office copy should be compared with the stock cards, and all goods which cannot be supplied from stock should be ordered, the number of the order being recorded upon the office and storekeeper's lists.

When the storekeeper has received the goods to make the list complete for the section, he notifies the foremen of the departments concerned, and also the office. It would be for the foremen to arrange for the work to be put in hand and carried out with the utmost economy and expedition.

Before commencing a job, all the material for each section of the work should be ready to be dealt with, as a great waste of money is always incurred when the work cannot be proceeded with in a straightforward and systematic manner, through materials not being to hand when required.

Timekeeper.—One of the greatest aids to discipline in a workshop is to have an efficient system of time-checking. This is now often effected by various mechanical devices connected with clock movements, but these have not yet arrived at that state of perfection to make a timekeeper unnecessary. A clock which automatically registers (by checks or other means) the times at which each employee enters and leaves the works, is a great assistance to the timekeeper, and whilst effecting the purpose for which it is installed, it prevents disputes.

The timekeeper should prepare daily a sheet recording the times of entry, exit, and total time for the day of each employee, for the use of the clerk checking the daily time sheets. The timekeeper should also prepare a weekly record sheet showing the time lost by each employee, so that those losing time habitually may be dealt with as may be necessary. Unpunctuality may mean considerable loss to an employer if it is not kept to the smallest possible limits, as the productive hours are reduced without a corresponding reduction in the indirect expenses.

Charts.—Of the many means devised for bringing to the notice of the officers directing a business, the rise and fall of the different factors operating towards its success or otherwise, none perhaps better fulfils the purpose than a system of graphic charts. A curve can be plotted in chart form to illustrate the fluctuations which occur in almost any particular, whether it be the rise and fall of the prices of materials,[1] the value of the orders received and of the sales made, and the amount of the departmental expenses, or the relation which these bear one to another, as shown in No. 1, Plate XLV.

[1] See Plates XLVII and XLVIII for fluctuations in the prices of tin, copper, zinc, and lead.

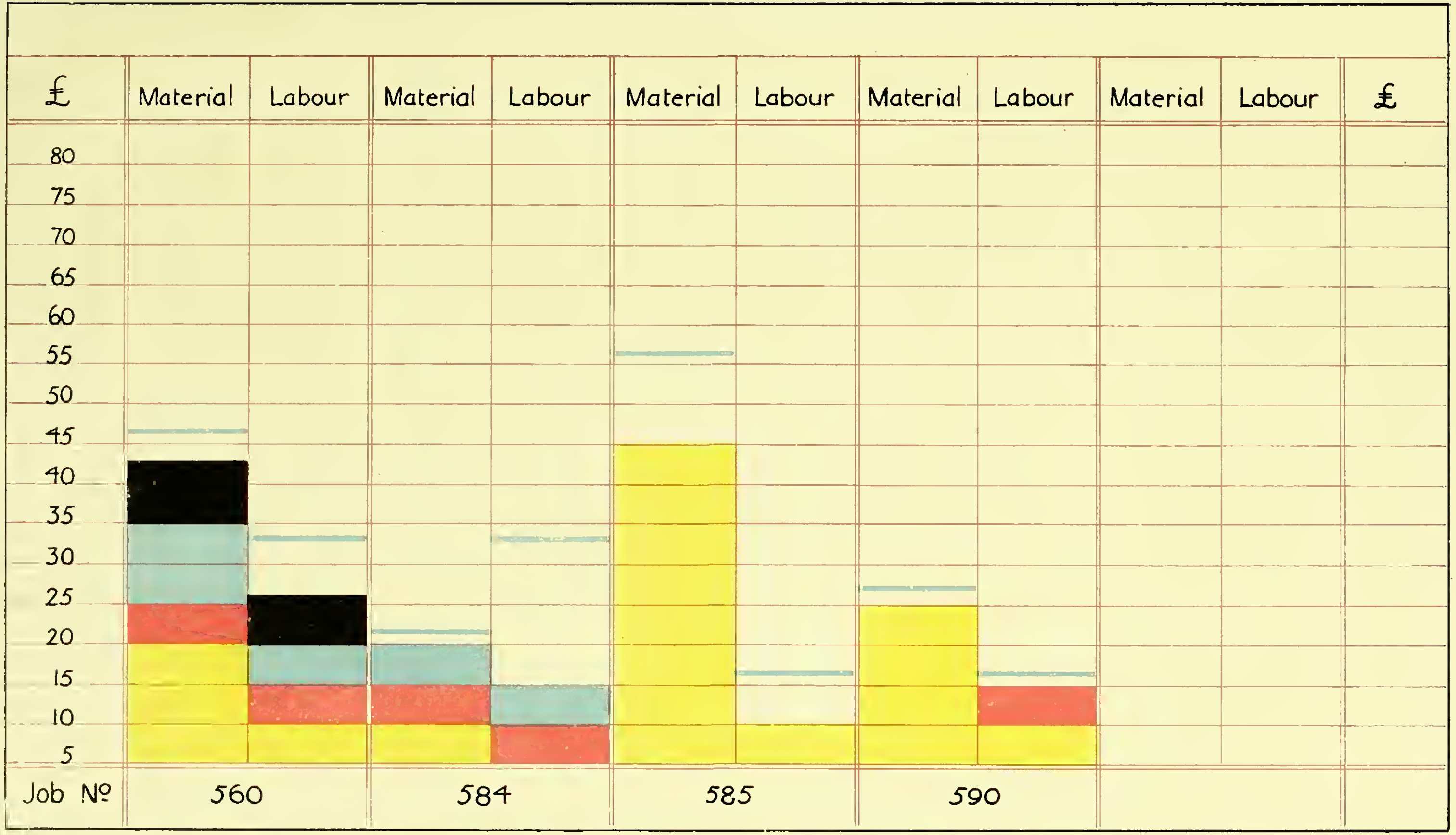


CHART SHOWING WEEKLY EXPENDITURE ON MATERIAL AND LABOUR

(Blue line indicates Estimated Expenditure)

Care must be taken that the expenditure in indirect labour does not increase or remain constant when the productive labour is declining. To check the indirect expenditure, a chart on the lines of that shown in No. 2, Plate XLV, should be prepared from the totals abstracted to compute departmental expenses.

The graphic chart is specially useful in recording weekly, by progressive totals, the **expenditures incurred in materials and labour** upon the works in hand, and the relation they bear to the total expenditure provided for in the original estimates. Plate XLVI shows a chart of this kind. It is assumed that separate estimates have been prepared for the materials and the labour in each case, and these estimates are marked by blue lines on the chart. The expenditure is then coloured on the chart week by week, orange being used for the first week, red for the second, blue for the third, and black for the fourth. Any other range of colours can of course be used. In the example given, job No. 560 has been in progress for four weeks, and expenditure has been incurred each week both for materials and labour. Job No. 584 has been in progress for three weeks, the expenditure for the first week having been for materials only. For job No. 590 all the materials were sent the first week, but the expenditure for labour was spread over two weeks. In many cases the work may go on for months, and it is in such cases that a chart of this kind is of the greatest use.

Good organization evolves a system so arranged that all details are anticipated, and that none shall escape attention, as a very small matter not provided for at the proper moment may, at some later period, entail a cost out of all proportion to its own value. As far as the means of the business will permit, it is profitable to introduce progressive measures, not only to improve the general organization and equipment of the works, but also for the health and comfort of the employees. By these means the employer can obtain and retain the services of high-class mechanics, from whom only the best results of production are obtainable, and will also save himself from many worries and losses.

APPENDICES

I. WATER SUPPLY

II. TRADE LISTS OF METAL SHEETS, TUBES, ETC.

III. TABLES AND MENSURATION

IV. TEMPERATURE

APPENDIX I.—WATER SUPPLY

Table for Converting Feet Head of Water into Pressure per Square Inch

Feet Head.	Pounds per Square Inch.	Feet Head.	Pounds per Square Inch.	Feet Head.	Pounds per Square Inch.	Feet Head.	Pounds per Square Inch.
1	·43	8	3·40	35	15·16	70	30·32
2	·87	9	3·90	40	17·32	75	32·48
3	1·30	10	4·33	45	19·49	80	34·65
4	1·73	15	6·50	50	21·65	85	36·81
5	2·17	20	8·66	55	23·82	90	38·98
6	2·60	25	10·83	60	25·99	95	41·14
7	3·03	30	12·99	65	28·15	100	43·31

Table for Converting Pressure per Square Inch into Feet Head of Water

Pounds per Sq. In.	Feet Head.	Pounds per Sq. In.	Feet Head.	Pounds per Sq. In.	Feet Head.	Pounds per Sq. In.	Feet Head.
1	2·31	8	18·47	35	80·81	70	161·63
2	4·62	9	20·78	40	92·36	75	173·17
3	6·93	10	23·09	45	103·90	80	184·72
4	9·24	15	34·63	50	115·45	85	196·26
5	11·54	20	46·18	55	126·99	90	207·81
6	13·85	25	57·72	60	138·54	95	219·35
7	16·16	30	69·27	65	150·08	100	230·90

Barometric Pressures at different Altitudes with Equivalent Head of Water and the Vertical Suction Lift of Pumps

Altitude in Feet, &c.	Barometric Pressure in Pounds per Square Inch.	Equivalent Head of Water in Feet.	Practical Suction Lift of Pumps in Feet.
Sea level	14·70	33·95	25
1320 ($\frac{1}{4}$ mile)	14·02	32·38	24
2640 ($\frac{1}{2}$ mile)	13·33	30·79	23
3960 ($\frac{3}{4}$ mile)	12·66	29·24	21
5280 (1 mile)	12·02	27·76	20

Table showing the Velocity in Feet per Second and the Supply in Gallons per Minute for Pipes flowing full

Calculated by Neville's Formula[1]—$v = 140\sqrt{RS} - 11\sqrt[3]{RS}$

Diameter of Pipes.	Head of Water divided by Length of Pipe.									
	$\frac{1}{1000}$		$\frac{1}{100}$		$\frac{1}{10}$		$\frac{1}{2}$		$\frac{1}{1}$	
In.	Velocity in Feet per Second.	Supply in Gallons per Minute.	Velocity in Feet per Second.	Supply in Gallons per Minute.	Velocity in Feet per Second.	Supply in Gallons per Minute.	Velocity in Feet per Second.	Supply in Gallons per Minute.	Velocity in Feet per Second.	Supply in Gallons per Minute.
$\frac{3}{8}$	·173	·05	·770	·22	2·90	·83	7·02	2·01	10·19	2·92
$\frac{1}{2}$	·212	·11	·911	·46	3·40	1·36	8·20	4·18	11·89	6·06
$\frac{3}{4}$	·278	·32	1·16	1·33	4·26	4·89	10·19	11·69	14·75	16·92
1	·336	·69	1·37	2·79	4·99	10·17	11·89	24·25	17·18	35·04
$1\frac{1}{4}$	·388	1·24	1·56	4·96	5·63	17·95	13·39	42·67	19·33	61·61
$1\frac{1}{2}$	·436	2·00	1·73	7·93	6·22	28·54	14·75	67·70	21·28	97·68
$1\frac{3}{4}$	·481	3·00	1·89	11·79	6·76	42·23	16·01	99·99	23·08	144·20
2	·522	4·26	2·04	16·61	7·27	59·29	17·18	140·18	24·76	202·05
3	·670	12·30	2·56	46·99	9·04	165·99	21·28	390·73	30·63	562·22
4	·798	26·03	3·01	98·60	10·55	344·32	24·76	808·21	35·60	1162·0
5	·911	46·48	3·40	173·70	11·89	606·13	27·84	1419·8	40·01	2040·2
6	1·02	74·64	3·76	277·10	13·10	959·72	30·63	2248·9	44·00	3230·8

R = the hydraulic radius or mean depth in feet

$$= \frac{\text{Sectional area}}{\text{perimeter}} = \text{in pipes } \frac{\text{diameter}}{4} = \frac{d}{4}$$

S = the sine of the inclination of the pipe

$$\text{or } \frac{\text{total fall}}{\text{total length}} = \frac{H}{L}.$$

Theoretical Velocity due to Different Heads of Water

H = Head of Water in feet. v = Velocity in feet per minute.
V = Velocity in feet per second. $V = 8·025\sqrt{H}$. $v = 482\sqrt{H}$.

H	V	v	H	V	v	H	V	v
1	8·0	482	15	31	1866	65	65	3886
2	11·3	681	16	32	1928	70	67	4032
3	13·9	835	17	33	1987	75	69	4174
4	16·0	964	18	34	2056	80	72	4311
5	18·0	1078	19	35	2100	85	74	4443
6	19·7	1180	20	36	2155	90	76	4573
7	21·0	1275	25	40	2410	95	78	4698
8	23·0	1363	30	44	2640	100	80	4820
9	24·0	1446	35	47	2851	125	90	5389
10	25·0	1524	40	51	3048	150	98	5903
11	26·5	1598	45	54	3233	200	113	6816
12	28·0	1669	50	57	3408	250	127	7621
13	29·0	1737	55	59	3574	300	139	8348
14	30·0	1803	60	62	3733	350	150	9017

Note.—Columns V and v are also falling-body velocities due to different heights.

[1] Extracted from Hurst's *Handbook.*

Table showing the Theoretical Quantity of Water, in Gallons, raised per hour by ordinary Lift Pumps, if worked 25 strokes per minute, 6-, 8-, and 12-inch stroke.

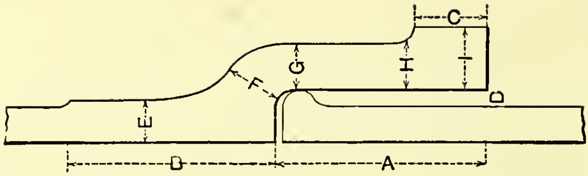
Diameter of Pump. Inches.	Single Pumps. Quantity raised per hour.			Double Pumps. Quantity raised per hour.			Treble Pumps. Quantity raised per hour.		
	6-in. Stroke.	8-in. Stroke.	12-in. Stroke.	6-in. Stroke.	8-in. Stroke.	12-in. Stroke.	6-in. Stroke.	8-in. Stroke.	12-in. Stroke.
2	102	136	204	205	274	411	308	410	616
2½	160	212	320	272	362	544	480	640	960
3	231	308	462	461	614	923	692	920	1384
3½	313	416	627	627	836	1254	940	1252	1880
4	410	546	819	818	1090	1637	1228	1636	2456
4½	518	690	1036	1036	1380	2072	1554	2072	3108
5	639	852	1279	1278	1706	2557	1918	2556	3836
5½	774	1032	1548	1548	2064	3096	2322	3096	4644
6	920	1226	1841	1841	2454	3683	2762	3682	5524
6½	1081	1440	2162	2161	2882	4323	3242	4322	6484
7	1253	1670	2507	2506	3342	5013	3760	5012	7520
7½	1438	1918	2877	2877	3836	5755	4319	5758	8638
8	1636	2180	3372	3272	4362	6544	4908	6544	9816

Diameter, Thickness, Weight per Foot, etc., of Cast-iron Water Pipes

Internal Diameter in Inches.	Thickness in Inches.	Weight in Pounds.	Safe Head of Water in Feet.	Internal Diameter in Inches.	Thickness in Inches.	Weight in Pounds.	Safe Head of Water in Feet.
2	$\frac{3}{8}$	8·74	300	5	$\frac{3}{8}$	19·78	120
2	$\frac{7}{16}$	10·46	600	5	$\frac{7}{16}$	23·35	240
3	$\frac{3}{8}$	12·43	200	5	$\frac{1}{2}$	26·99	360
3	$\frac{7}{16}$	14·77	400	5	$\frac{5}{8}$	34·53	600
3	$\frac{1}{2}$	17·18	600	6	$\frac{3}{8}$	23·49	100
4	$\frac{3}{8}$	16·10	150	6	$\frac{7}{16}$	27·67	200
4	$\frac{7}{16}$	19·06	300	6	$\frac{1}{2}$	31·82	300
4	$\frac{1}{2}$	22·09	450	6	$\frac{5}{8}$	40·67	500
4	$\frac{9}{16}$	25·19	600	6	$\frac{11}{16}$	45·15	600

Dimensions of Spigot and Socket Joints in Cast-iron Water Pipes

Diameter of Pipe.	A	B	C	D
2 in.	3 in.	3 in.	$\frac{3}{4}$ in.	$\frac{1}{4}$ in.
3 ,,	3 ,,	3 ,,	$\frac{3}{4}$,,	$\frac{1}{4}$,,
4 ,,	$3\frac{1}{8}$,,	$3\frac{1}{8}$,,	$\frac{3}{4}$,,	$\frac{1}{4}$,,
5 ,,	$3\frac{1}{4}$,,	$3\frac{1}{4}$,,	$\frac{7}{8}$,,	$\frac{3}{8}$,,
6 ,,	$3\frac{1}{2}$,,	$3\frac{1}{2}$,,	$\frac{7}{8}$,,	$\frac{3}{8}$,,

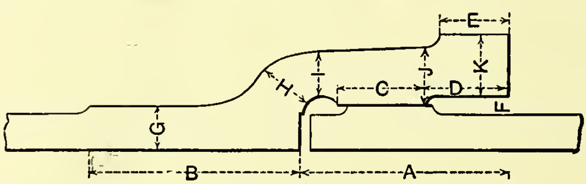


Thicknesses of Metal in Spigot and Socket Joints in Cast-iron Pipes

Thickness of Pipe.	E	F	G	H	I
$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$\frac{5}{8}$ in.	$\frac{11}{16}$ in.	$\frac{7}{8}$ in.
$\frac{7}{16}$ "	$\frac{9}{16}$ "	$\frac{15}{16}$ "	$\frac{11}{16}$ "	$\frac{3}{4}$ "	$\frac{15}{16}$ "
$\frac{1}{2}$ "	$\frac{5}{8}$ "	1 "	$\frac{3}{4}$ "	$\frac{13}{16}$ "	$1\frac{1}{16}$ "
$\frac{9}{16}$ "	$\frac{11}{16}$ "	$1\frac{1}{16}$ "	$\frac{13}{16}$ "	$\frac{7}{8}$ "	$1\frac{1}{8}$ "
$\frac{5}{8}$ "	$\frac{3}{4}$ "	$1\frac{1}{8}$ "	$\frac{7}{8}$ "	$\frac{15}{16}$ "	$1\frac{3}{16}$ "

Dimensions of Turned and Bored Joints in Cast-iron Pipes

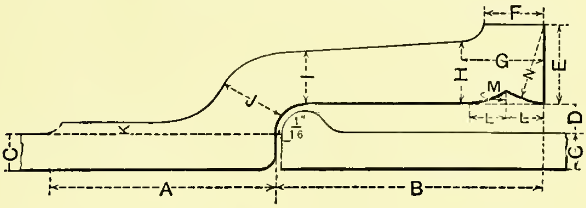
Diameter of Pipe.	A	B	C	D	E	F
2 in.	3 in.	3 in.	$1\frac{1}{4}$ in.	$1\frac{1}{4}$ in.	$\frac{7}{8}$ in.	$\frac{1}{4}$ in.
3 "	3 "	3 "	$1\frac{1}{4}$ "	$1\frac{1}{4}$ "	$\frac{7}{8}$ "	$\frac{1}{4}$ "
4 "	3 "	3 "	$1\frac{1}{4}$ "	$1\frac{1}{4}$ "	$\frac{7}{8}$ "	$\frac{1}{4}$ "
5 "	$3\frac{1}{2}$ "	$3\frac{1}{2}$ "	$1\frac{3}{8}$ "	$1\frac{3}{8}$ "	1 "	$\frac{3}{8}$ "
6 "	$3\frac{1}{2}$ "	$3\frac{1}{2}$ "	$1\frac{3}{8}$ "	$1\frac{3}{8}$ "	1 "	$\frac{3}{8}$ "



Thicknesses of Metal in Turned and Bored Joints in Cast-iron Water Pipes

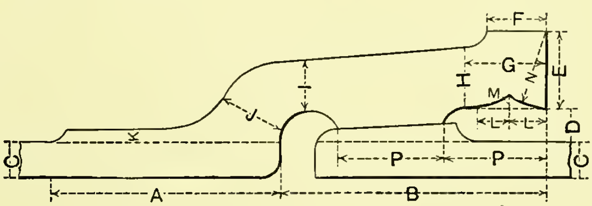
Thickness of Pipe.	G	H	I	J	K
$\frac{3}{8}$ in.	$\frac{1}{2}$ in.	$\frac{3}{4}$ in.	$\frac{5}{8}$ in.	$\frac{11}{16}$ in.	$\frac{7}{8}$ in.
$\frac{7}{16}$ "	$\frac{9}{16}$ "	$\frac{15}{16}$ "	$\frac{11}{16}$ "	$\frac{3}{4}$ "	$\frac{15}{16}$ "
$\frac{1}{2}$ "	$\frac{5}{8}$ "	1 "	$\frac{3}{4}$ "	$\frac{13}{16}$ "	$1\frac{1}{16}$ "
$\frac{9}{16}$ "	$\frac{11}{16}$ "	$1\frac{1}{16}$ "	$\frac{13}{16}$ "	$\frac{7}{8}$ "	$1\frac{1}{8}$ "
$\frac{5}{8}$ "	$\frac{3}{4}$ "	$1\frac{1}{8}$ "	$\frac{7}{8}$ "	$\frac{15}{16}$ "	$1\frac{3}{16}$ "

Table Showing Dimensions in Inches of Plain Socket Joints for Cast-iron Water Pipes, with Recess for Lead



Bore in Inches.	A	B	C	D	E	F	G	H	I	J	K	L	M	N Radius.
2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$	$2\frac{1}{2}$	3	Thickness of Pipe.	$\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	1	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{16}$
5, $5\frac{1}{2}$, 6	3	$3\frac{1}{2}$		$\frac{3}{8}$	1	$\frac{7}{8}$	$1\frac{1}{8}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{16}$

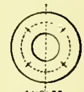
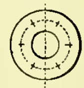
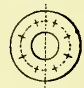
Table Showing Dimensions in Inches of Turned and Bored Joints for Cast-iron Water Pipes, with Recess for Lead



Bore in Inches.	A	B	C	D	E	F	G	H	I	J	K	L	M	N Radius.	P
2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$	$2\frac{1}{2}$	3	Thickness of Pipe.	$\frac{1}{4}$	$\frac{7}{8}$	$\frac{3}{4}$	1	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{16}$	$1\frac{1}{4}$
5, $5\frac{1}{2}$, 6	3	3		$\frac{3}{8}$	1	$\frac{7}{8}$	$1\frac{1}{8}$	$\frac{13}{16}$	$\frac{11}{16}$	$\frac{7}{8}$	$\frac{1}{8}$	$\frac{1}{2}$	$\frac{1}{8}$	$1\frac{1}{16}$	$1\frac{3}{4}$

Taper of bored portion $\frac{1}{32}$ in. per inch of length.

Table of Dimensions of Flanges of Cast-iron Pipes, Valves, etc.

Bore in Inches.	Flanges.		Diameter of Bolt-hole Circle. Inches.	Bolts.		Weight of Bolts and Nuts per Joint. Pounds.	Diagram Showing Position of Bolt-holes with reference to Vertical Line through Centre of Bore.
	Diameter. Inches.	Thickness. Inches.		Diameter. Inches.	No.		
2	$6\frac{1}{2}$	$\frac{9}{16}$	$4\frac{3}{4}$			2·02	
$2\frac{1}{2}$	7	$\frac{5}{8}$	$5\frac{1}{2}$			2·07	
3	$7\frac{1}{2}$	$\frac{5}{8}$	6	$\frac{5}{8}$		2·07	
$3\frac{1}{2}$	8	$\frac{5}{8}$	$6\frac{3}{4}$			2·07	4 HOLES
4	$9\frac{1}{2}$	$\frac{3}{4}$	$7\frac{3}{4}$			3·52	
$4\frac{1}{2}$	10	$\frac{3}{4}$	$8\frac{1}{4}$	$\frac{3}{4}$	4	3·52	
5	$10\frac{1}{2}$	$\frac{7}{8}$	$8\frac{3}{4}$			3·66	6 HOLES
$5\frac{1}{2}$	11	$\frac{7}{8}$	$9\frac{1}{4}$			5·54	
6	12	$\frac{7}{8}$	10	$\frac{7}{8}$		5·54	
$6\frac{1}{2}$	13	$\frac{7}{8}$	11			5·54	8 HOLES

Messrs. Glenfield & Kennedy, Ltd. (Kilmarnock), manufacture spigot-and-socket cast-iron water-pipes in 9-foot lengths as below, cast in dry sand vertically, with sockets down, and tested at the foundry to the pressures named, and coated with Dr. Angus Smith's composition:—

Internal Diameter.	Tested to a Water pressure of															
	400 Vertical Feet.				500 Vertical Feet.				600 Vertical Feet.				700 Vertical Feet.			
	Thickness.	Normal Weight of each Pipe.			Thickness.	Normal Weight of each Pipe.			Thickness.	Normal Weight of each Pipe.			Thickness.	Normal Weight of each Pipe.		
In.	In.	Cwt.	qr.	lb.	In.	Cwt.	qr.	lb.	In.	Cwt.	qr.	lb.	In.	Cwt.	qr.	lb.
3	·368	1	0	10	·375	1	0	14	·400	1	0	23	·428	1	1	4
4	·375	1	1	24	·397	1	2	6	·420	1	2	16	·443	1	2	26
5	·405	1	3	22	·428	2	0	9	·451	2	0	22	·473	2	1	6
6	·437	2	2	0	·459	2	2	14	·481	2	3	0	·502	2	3	14
7	·450	3	0	0	·473	3	0	18	·496	3	1	8	·518	3	1	20
8	·460	3	2	0	·485	3	2	21	·510	3	3	14	·535	4	0	17
9	·480	4	0	7	·506	4	1	3	·532	4	2	0	·560	4	3	0

APPENDIX II.—TRADE LISTS OF METAL SHEETS, TUBES, ETC.

Composition Gas Pipe

	In coils about ½ cwt. each.		In coils about ½ cwt. each.
$\frac{1}{8}$ in.	3 oz. per yard.	$\frac{9}{16}$ in.	28 oz. per yard.
$\frac{3}{16}$,, ...	5 oz. ,,	$\frac{5}{8}$,, ...	46 oz. ,,
$\frac{1}{4}$,, ...	9 oz. ,,	$\frac{3}{4}$,, ...	$3\frac{1}{4}$ lb. ,,
$\frac{5}{16}$,, ...	13 oz. ,,	$\frac{7}{8}$,, ...	4 lb. ,,
$\frac{3}{8}$,, ...	17 oz. ,,	1 ,, ...	5 lb. ,,
$\frac{7}{16}$,, ...	21 oz. ,,	$1\frac{1}{4}$,, ...	$6\frac{1}{4}$ lb. ,,
$\frac{1}{2}$,, ...	26 oz. ,,		

Other sizes and lengths can also be made.

Simplex Steel Conduits (Light and Heavy Gauge) for Electric-Light Wiring

List External Diameter ...	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.	$1\frac{1}{4}$ in.	$1\frac{1}{2}$ in.	2 in.	
Exact External Diameter...	·5	·625	·75	·875	1·0	1·25	1·5	2·0	Light Gauge for socket junctions.
Exact Internal Diameter...	·42	·545	·654	·779	·904	1·138	1·372	1·872	
Thickness S.W.G.	19	19	18	18	18	17	16	16	
Weight (lb. per 100 ft.) ...	21	26	38	45	51	74	102	137	
Feet per Ton	10,600	8620	5900	5000	4390	3030	2190	1630	
Exact Internal Diameter...	·388	·497	·606	·731	·856	1·106	1·34	1·816	Heavy Gauge for screwed junctions.
No. of Threads per inch ...	18	18	16	16	16	16	14	14	
Thickness S.W.G.	17	16	15	15	15	15	14	13	
Weight (lb. per 100 ft.) ...	26	40	54	64	74	94	126	194	
Feet per Ton	8700	5600	4150	3500	3030	2380	1780	1160	

Milled Lead

In sheets 30 to 40 ft. long, 7 ft. wide

3 lb. per square foot	= $\frac{1}{20}$ in.	Nearest Birmingham Wire Gauge	18
4 ,, ,, ,,	= $\frac{1}{15}$,,	,, ,, ,,	16
5 ,, ,, ,,	= $\frac{1}{12}$,,	,, ,, ,,	14
6 ,, ,, ,,	= $\frac{1}{10}$,,	,, ,, ,,	12
7 ,, ,, ,,	= $\frac{1}{9}$,,	,, ,, ,,	11
8 ,, ,, ,,	= $\frac{1}{8}$,,	,, ,, ,,	

Can be supplied of any weight, say from 1 lb. to 20 lb. per square foot.

Sheet Lead is milled specially for chemical works, and is guaranteed wholly of soft pig lead.

Cast Lead

Sheets are cast in different sizes by different firms, but common sizes are 14 ft. by 3 ft. and 14 ft. by 5 ft. Nothing lighter than 7 to 8 lb. per square foot is recommended. Sheets of any desired weight in excess of this can be obtained.

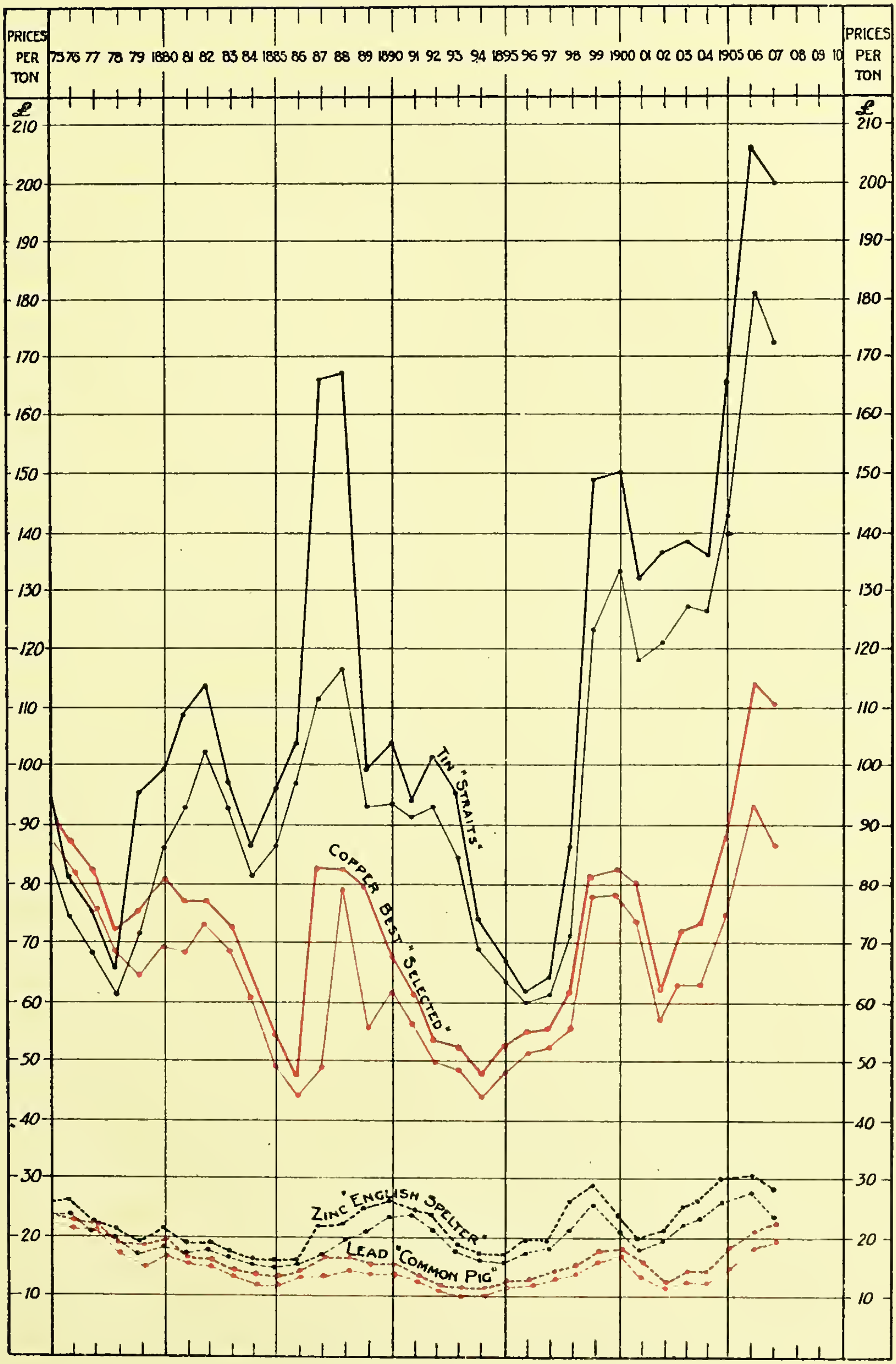
Lead Water Pipe

													In 15-ft. lengths, and in 60-ft. coils, or can be had in 80-ft. or 120-ft. coils.
¼ in.	10	15	20	25	...	...	...	...	...	...	...	...	lb. per 15 ft.
	2	3	4	5	...	...	...	...	...	...	...	...	lb. per yard.
⅜ in.	10	15	20	25	30	...	...	...	...	...	...	...	lb. per 15 ft.
	2	3	4	5	6	...	...	...	...	...	...	...	lb. per yard.
½ in.	15	18	20	22	25	28	30	35	40	45	...	...	lb. per 15 ft.
	3	3½	4	4½	5	5½	6	7	8	9	...	...	lb. per yard.
													In 15-ft. lengths, and in 60-ft. coils, or can be had in 90-ft coils.
9/16 in.	16	18	22	...	...	...	...	...	...	...	...	...	lb. per 15 ft.
	3¼	3½	4½	...	...	...	...	...	...	...	...	...	lb. per yard.
⅝ in.	18	22	27	30	35	40	45	...	...	...	...	...	lb. per 15 ft.
	3½	4½	5½	6	7	8	9	...	...	...	...	...	lb. per yard.
¾ in.	22	24	26	28	32	36	40	45	50	55	60	...	lb. per 15 ft.
	4½	5	5¼	5½	6½	7¼	8	9	10	11	12	...	lb. per yard.
													In 15-ft. lengths, and in 60-ft. coils, or can be had in 75-ft coils.
1 in.	28	36	42	45	48	52	56	60	64	70	80	...	lb. per 15 ft.
	5½	7¼	8½	9	9½	10½	11¼	12	13	14	16	...	lb. per yard.
													In 12-ft. lengths, and in 36-ft. coils.
1¼ in.	28	32	36	42	48	52	56	60	64	72	80	88	lb. per 12 ft.
	7	8	9	10½	12	13	14	15	16	18	20	22	lb. per yard.
1½ in.	36*	42	48	56	63	72	84	96	...	...	...	...	lb. per 12 ft.
	9*	10½	12	14	15¾	18	21	24	...	...	...	...	lb. per yard.
1¾ in.	56*	70	84	96	112	...	...	...	...	...	...	...	lb. per 12 ft.
	14*	17½	21	24	28	...	...	...	...	...	...	...	lb. per yard.
2 in.	48*	56*	64*	72	84	96	112	120*	...	...	...	...	lb. per 12 ft.
	12*	14*	16*	18	21	24	28	30*	...	...	...	...	lb. per yard.

Marked thus (*) in 12-ft. lengths only.

Lead Soil Pipe

	Equal to	5	6	7	8	9	10 lb. sheet lead.
							In 12-ft. lengths.
2 in.	... ...	—	40	—	—	—	— lb. per 12 ft.
							In 10-ft., 12-ft., and 14-ft. lengths.
2½ in.	... ...	34	41	48	55	—	— lb. per 10 ft.
3 in.	... ...	41	49	57	66	74	82 „ „
3½ in.	... ...	47	57	67	76	86	95 „ „
4 in.	... ...	54	65	76	87	98	109 „ „
4½ in.	... ...	—	73	85	97	—	— „ „
5 in.	... ...	—	81	94	107	—	— „ „
6 in.	... ...	—	—	—	128	—	— „ „



HIGHEST AND AVERAGE PRICES OF TIN, COPPER, ZINC, AND LEAD

from 1875 to 1907

Lead Soil Pipe

As Specified by the London County Council

3½ in.	... 65 lb. per 10-ft. length.	5 in. ...	... 92 lb. per 10-ft. length.
4 in.	... 74 „ „	6 in. ...	... 110 „ „

Lead Barrel

In 10-ft. and 12-ft. lengths.

2¼ in.	96	...	...	...	...	...	lb. per 10 ft.
	29	...	...	...	...	...	lb. per yard.
2½ in.	84	96	120	...	...	...	lb. per 10 ft.
	25¼	29	36	...	...	...	lb. per yard.
3 in.	116	134	150	...	...	...	lb. per 10 ft.
	35	40	45	...	...	...	lb. per yard.
3½ in.	135	156	166	175	...	...	lb. per 10 ft.
	40½	47	50	52½	...	...	lb. per yard.
4 in.	156	166	184	196	250	...	lb. per 10 ft.
	47	50	55	59	75	...	lb. per yard.
4½ in.	200	250	...	...	...	...	lb. per 10 ft.
	60	75	...	...	...	...	lb. per yard.
5 in.	254	280	...	...	...	...	lb. per 10 ft.
	76	84	...	...	...	...	lb. per yard.
6 in.	200	267	330	...	...	...	lb. per 10 ft.
	66	80	99	...	...	...	lb. per yard.

Other sizes and lengths can also be made.

Lead Gas Pipe

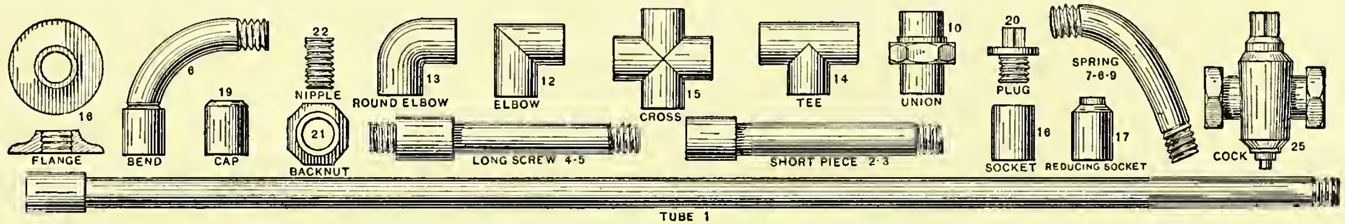
$\frac{1}{8}$ in.	... 3 oz. per yard.	$\frac{9}{16}$ in.	... 28 oz. per yard.
$\frac{3}{16}$ in.	... 5 „ „	$\frac{5}{8}$ in.	... 46 „ „
$\frac{1}{4}$ in.	... 9 „ „	$\frac{3}{4}$ in.	... 3¼ lb. „
$\frac{5}{16}$ in.	... 13 „ „	$\frac{7}{8}$ in.	... 4 „ „
$\frac{3}{8}$ in.	... 17 „ „	1 in.	... 5 „ „
$\frac{7}{16}$ in.	... 21 „ „	1¼ in.	... 6¼ „ „
$\frac{1}{2}$ in.	... 26 „ „		

In coils about ½ cwt. each.

Lead Rope for Caulking Cast-iron Pipes

Diameter of pipe in inches ...	4	5 and 6	9	12
„ rope „ ...	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$

Trade Price List of Wrought-iron Tubes and Fittings, for Gas, Water, and Steam.



No.	Internal Diameter in Inches.		⅛ and ¼	⅜	½	¾	1	1¼	1½	1¾	2	2¼	2½	2¾	3	3½	4	4½	5	5½	6
	Tubes.																				
1	Tubes, 2 ft. long and over	per ft.	/3½	/4	/5	/6½	/9	1/	1/4	1/8	1/10	2/6	2/9	3/	3/3	4/3	4/9	5/6	6/	6/9	7/6
2	Pieces, 12 to 23½ in. long	each	/9	/10	1/1	1/4	1/10	2/6	3/4	4/3	4/9	6/9	8/	9/	10/	13/6	15/6	21/	24/	28/6	32/6
3	Ditto, 4 to 11½ in. long ...	,,	/5½	/6	/8	/10	1/2	1/6	2/	2/7	3/	4/3	5/3	6/	6/9	9/3	10/9	15/6	18/	21/9	25/3
4	Longscrews, 12 to 23½ in.	,,	/10	/11	1/2	1/5	2/	2/8	3/7	4/8	5/3	7/6	9/	10/	11/6	15/6	17/	23/	26/6	31/6	35/6
5	Ditto, 3 to 11½ in. ...	,,	/6½	/7	/9	/11	1/3	1/8	2/3	3/	3/3	4/8	6/3	6/7	8/	10/9	12/3	17/	20/	24/	28/
23	Barrel Nipples	,,	/5	/5	/6	/7	/9	1/	1/4	1/8	1/9	2/6	3/	3/6	4/	6/	7/	10/	12/6	15/	20/
6	Bends	,,	/7	/8	/10	1/	1/6	2/6	3/	4/	5/	8/6	12/	15/	18/	25/	32/6	80/	105/	135/	150/
7, 8, 9	Springs, not socketed ...	,,	/5	/6	/7	/9	1/1½	1/11½	2/3½	3/1	3/11	6/9	9/6	12/	14/6	20/	26/6	70/	93/	120/	132/
	Fittings.																				
10, 11	Socket or Pipe Union ...	each	2/	2/6	3/	4/	5/6	6/9	8/	9/	10/	15/	17/6	20/	22/6	27/6	35/	48/	66/	84/	105/
12	Elbows, Square	,,	/8½	/9	/10	1/	1/4	1/10	2/5	3/	3/10	6/3	9/	11/6	14/	22/	28/	75/	95/	120/	150/
13	Ditto, Round	,,	/9½	/11	1/	1/3	1/6	2/1	2/7	3/6	4/6	6/9	10/	13/	17/	25/	32/	75/	95/	120/	150/
14	Tees	,,	/9	/10	/11	1/2	1/5	2/	2/6	3/2	4/3	6/6	9/6	12/6	16/6	24/	30/	78/	98/	125/	155/
15	Crosses	,,	1/4	1/6	1/11	2/4	3/	4/	4/10	6/	7/9	14/	21/4	28/	40/	56/	66/8	175/	220/	280/	350/
16	Sockets, Plain	,,	/2	/2	/3	/3½	/4½	/6½	/8½	/11	1/1	1/9	2/6	3/	3/6	5/	6/	10/	12/	15/	18/
17	Ditto, Diminished ...	,,	/3	/4	/5	/6	/7	/9	/11	1/2	1/4	2/3	3/3	4/	5/	7/	9/	25/	35/	45/	55/
18	Flanges	,,	/9	/10	1/	1/2	1/4	1/9	2/	2/3	2/9	4/	5/	6/9	8/6	10/	11/6	16/	18/	23/	27/
19	Caps	,,	/3½	/3½	/5	/6	/8	1/	1/3	1/7	2/	3/	4/4	5/3	6/	9/9	10/6	25/	30/	37/6	45/
20	Plugs	,,	/3	/3	/4	/5	/6	/8	/10	1/	1/3	2/	2/6	3/6	4/9	7/	10/	22/	30/	39/	48/
21	Backnuts	,,	/2	/2	/3	/3½	/5	/6	/8	/10	1/1	1/9	2/3	3/	3/6	4/6	5/6	14/	18/	21/	26/

	Internal Diameter in Inches.		$\frac{1}{8}$ and $\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6
	Fittings—(*Cont.*)																				
22	Nipples	each	/2	/2	/3	/3½	/4	/6	/8	/10	1/	1/9	2/3	3/	3/6	4/6	5/6	14/	18/	21/	26/
24	Union Bends	,,	2/6	3/	3/9	5/	6/3	8/6	10/	11/6	13/6	21/	27/	32/	37/	49/	58/	78/	100/	135/	160/
25	Main Cocks	,,	2/3	2/9	3/6	4/6	6/6	8/6	11/	14/	18/	27/	40/	50/	60/	85/	110/	210/	270/	360/	420/
26	Ditto with Brass Plugs...	,,	—	7/	8/9	11/6	16/	21/6	28/	35/	45/	68/	100/	112/	125/	212/	250/	360/	450/	570/	660/
27	Round Way Cocks ...	,,	—	3/6	4/	5/6	7/6	10/	13/	17/6	22/	38/	60/	65/	75/	120/	160/	—	—	—	—
28	Ditto, with Brass Plugs...	,,	—	10/6	12/	16/6	22/6	30/	39/	52/6	66/	114/	180/	195/	225/	360/	480/	—	—	—	—
29	Cock Spanners, Wrought	,,	—	1/6	1/8	2/2	2/8	3/2	3/6	4/	4/3	4/9	6/	7/6	9/	12/	14/	16/	19/	22/	24/
30	Ditto, Malleable Cast ...	,,	—	1/	1/4	1/8	2/	2/4	3/	3/6	4/	4/9	6/	7/6	9/	12/	14/	16/	19/	22/	24/
31	Siphon Boxes, 1-quart ...	,,	—	—	22/9	23/	23/4	24/	24/6	25/2	26/3	28/6	—	—	—	—	—	—	—	—	—
32	Ditto 2-quarts ...	,,	—	—	—	27/	27/4	28/	28/6	29/2	30/3	32/6	35/6	38/6	42/6	—	—	—	—	—	—
33	Ditto 3-quarts ..	,,	—	—	—	32/	32/4	33/	33/6	34/2	35/3	37/6	40/6	43/6	47/6	55/6	61/6	—	—	—	—
34	Ditto 4-quarts ...	,,	—	—	—	38/	38/4	39/	39/6	40/2	41/3	43/6	46/6	49/6	53/6	61/6	67/6	—	—	—	—

NOTES[1]

Tubes, Screwed and Socketed, supplied in random or exact lengths from 2 ft. to 12 ft., and all exact lengths over 12 ft. are charged $2\frac{1}{2}\%$ less gross discount.

Tubes, not Screwed, or Socketed, supplied in random lengths of any length are charged at the current discount with an **extra allowance** of $2\frac{1}{2}\%$ off the net.

Tubes, not Screwed, or Socketed, cut to exact lengths of any length, are charged at the **same discount** as tubes screwed and socketed in random lengths.

Tubes Screwed and sent **without sockets**, are charged at the current discount with an **extra allowance** of $1\frac{1}{4}\%$ off the net.

Tubes and Fittings, coated inside and outside with Dr. Angus Smith's solution, are charged at $2\frac{1}{2}\%$ less gross discount.

Tubes and Fittings, painted red, will be charged at **Steam Discounts.**

Tubes and Fittings, painted blue, will be charged at **Water Discounts.**

All Short Lengths 4 in. to 2 ft., whether random or exact, to be considered pieces, and sold at gross prices of pieces, less same discounts as tubes of random lengths.

Tubes of Intermediate Diameters are charged at the list price of the next larger sizes.

Springs, if Socketed, will be charged extra for the sockets at list prices.

Orders not amounting to £2 net value will be sent carriage forward.

[1] The list and notes printed above are copied from the Trade List issued in 1907, which cancels all other lists. It may be useful to point out that the price list applies to the three qualities of tubes and fittings, namely *gas*, *water*, and *steam*, and that the difference in value is adjusted in the discounts allowed off the list prices; thus, the greatest or gross discount is allowed for tubes and fittings of *gas* strength (black), the discount for *water* strength (blue) being less by $2\frac{1}{2}\%$, and that for *steam* strength (red) being less than the gross discount by 5%. For galvanized tubes and fittings of any quality the gross discount for that quality is reduced by $12\frac{1}{2}\%$. The amount of gross discount allowed, and the proportionate discounts for the various qualities are varied as required, according to the price of iron, labour, &c., but the list prices may remain the same for a great number of years.

Sheet Zinc

Nearest Standard Wire Gauge.	Gauge.	Approximate Weight per square foot.			Approximate Weight of Sheets.							
					7 ft. by 3 ft.			Sheets in Casks of about 10 cwt.	8 ft. by 3 ft.			Sheets in Casks of about 10 cwt.
		lb.	oz.	drm.	lb.	oz.	drm.		lb.	oz.	drm.	
42	1	0	2	5	...	...	...	...	...	...	...	...
38	2	0	3	4	...	...	...	...	...	...	...	...
35	3	0	3	15	5	2	11	213	5	14	8	187
33	4	0	4	13	6	5	1	175	7	3	8	153
31	5	0	5	11	7	7	7	147	8	8	8	129
30	6	0	6	11	8	12	7	126	10	0	8	110
29	7	0	7	12	10	2	12	108	11	10	0	95
26	8	0	8	14	11	10	6	95	13	5	0	83
25	9	0	10	5	13	8	9	81	15	7	8	71
24	10	0	11	7	15	0	3	73	17	2	8	64
23	11	0	13	5	17	7	9	63	19	15	8	55
22	12	0	15	2	19	13	10	56	22	11	0	49
	13	1	0	15	22	3	11	50	25	6	8	43
21	14	1	2	12	24	9	12	45	28	2	0	39
20	15	1	5	12	28	8	12	39	32	10	0	34
18	16	1	8	12	32	7	12	34	37	2	0	30
	17	1	11	11	36	5	7	30	41	8	8	27
17	18	1	14	11	40	4	7	27	46	0	8	24
	19	2	1	11	44	3	7	25	50	8	8	22
16	20	2	4	10	48	1	2	23	54	15	0	20
15	21	2	8	12	53	7	12	21	61	2	0	18
14	22	2	12	14	58	14	6	19	67	5	0	16
	23	3	1	1	64	6	5	17	73	9	8	15
13	24	3	5	3	69	12	15	16	79	12	8	14
12	25	3	9	5	75	3	9	15	85	15	8	13
11	26	3	13	7	80	10	3	14	92	2	8	12

Nos. 1 and 2 are only rolled to order and special dimensions.

Note.—As it is impossible to roll sheets exactly to any given weight or thickness, a slight deviation must be allowed.

Sheet Copper

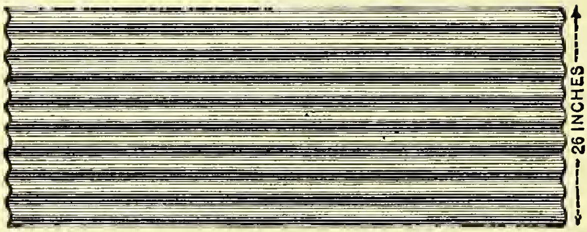
Standard Wire Gauge.	Weight per Square Foot.		Weight of Common Plates. 4 × 2 ft.		Weight of Scotch Plates. 4 × 3 ft. 6 in.		Standard Wire Gauge.	Weight per Square Foot.		Weight of Common Plates. 4 × 2 ft.		Weight of Scotch Plates. 4 × 3 ft. 6 in.	
No.	lb.	oz.	lb.	oz.	lb.	oz.	No.	lb.	oz.	lb.	oz.	lb.	oz.
1	14	0	112	0	196	0	16	3	0	24	0	42	0
2	13	0	104	0	182	0	17	2	12	22	0	38	8
3	12	0	96	0	168	0	18	2	4	18	0	31	8
4	11	0	88	0	154	0	19	2	0	16	0	28	0
5	10	2	81	0	141	12	20	1	12	14	0	24	8
6	9	8	76	0	133	0	21	1	8	12	0	21	0
7	8	8	68	0	119	0	22	1	6	11	0	19	4
8	7	10	61	0	106	12	23	1	3	9	8	16	10
9	7	0	56	0	98	0	24	1	0	8	0	14	0
10	6	4	50	0	87	8	25	0	14	7	0	12	4
11	5	8	44	0	77	0	26	0	13	6	8	11	6
12	5	0	40	0	70	0	27	0	11½	5	12	10	1
13	4	8	36	0	63	0	28	0	10	5	0	8	12
14	4	0	32	0	56	0	29	0	9	4	8	7	14
15	3	8	28	0	49	0	30	0	8	4	0	7	0

Seamless Copper Tubes

Gauge.	18		16		14		12		10		9		8		7		6		5		4		3	
Internal Diameter.	Approximate Weight per Foot Run.																							
Inches.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.	lb.	oz.
½		5¼		7		9		12⅛		16	—		—		—		—		—		—		—	
⅝		6½		8¾		11		15	1	3	1	8½	—		—		—		—		—		—	
¾		7½		10		13	1	1½	1	6	1	9½	1	12	2	0	—		—		—		—	
1		10		13	1	1	1	6½	1	12	2	0	2	4	2	8	2	13	—		—		—	
1¼		12	1	1	1	5	1	11	2	2½	2	7	2	12	3	1	3	6	—		—		—	
1½		15	1	4	1	8¾	2	0½	2	8½	2	14	3	4	3	9½	3	15	—		—		—	
1¾	1	1	1	6½	1	12½	2	5½	2	15	3	6	3	12	4	2	4	8¼	—		—		—	
2	1	3	1	10	2	0½	2	11	3	4½	3	12	4	3	4	10½	5	2	5	11	6	4¼	—	
2¼	1	5½	1	13	2	4	3	0	3	11	4	3	4	11	5	3	5	11	6	5	7	0	—	
2½	1	8	2	0	2	8	3	5	4	2	4	10	5	3	5	11	6	4	7	0	7	11	—	
2¾	1	10	2	3	2	12	3	10	4	8	5	1	5	10	6	4	6	13	7	10	8	6	—	
3	1	13	2	6	3	0	3	15	4	14	5	8	6	2	6	12	7	7	8	4	9	2	9	15
3½	2	1½	2	12½	3	8	4	9	5	10	6	6	7	2	7	14	8	10	9	9	10	8	11	7
4	2	6	3	2½	4	0	5	3	6	7	7	4	8	1	8	15	9	12	10	13	11	14	13	0
4½	2	11	3	9	4	7	5	13	7	3	8	2	9	1	10	0	10	15	12	2	13	5	14	8
5	2	15	3	15	4	15	6	7	7	15	9	0	10	0	11	1	12	2	13	6	14	11	16	1
5½	3	4	4	5	5	7	7	1	8	12	9	14	11	0	12	2	13	4	14	11	16	2	17	9
6	3	8½	4	11	5	14	7	11	9	8	10	11	11	15	13	3	14	7	15	15	17	8	19	2

Brazed Copper Tubes weigh more per lineal foot than seamless; but an exact multiple cannot be given, as the proportion of difference in weight varies with the thickness, the diameter, and the class of joint of the brazed tube.

Galvanized Corrugated-iron Sheets



Eight 3-in. Corrugations, covering 2 ft. wide when fixed. Usual gauges from No. 20 to No. 26.

Approximate Weight per Sheet in Pounds.							Approximate Number of Sheets per Ton.					
Length.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft	10 ft.	5 ft.	6 ft.	7 ft.	8 ft.	9 ft.	10 ft.
16 W.G.	$33\frac{1}{4}$	40	$46\frac{1}{2}$	$53\frac{1}{4}$	60	$66\frac{1}{2}$	67	56	48	42	37	34
18 W.G.	$26\frac{3}{4}$	32	$37\frac{1}{4}$	$42\frac{3}{4}$	48	$53\frac{1}{4}$	84	70	60	52	46	42
20 W.G.	$21\frac{1}{4}$	$25\frac{1}{2}$	$29\frac{3}{4}$	34	$38\frac{1}{4}$	$42\frac{1}{2}$	105	88	75	66	58	53
22 W.G.	$16\frac{3}{4}$	20	$23\frac{1}{4}$	$26\frac{1}{2}$	30	$33\frac{1}{2}$	134	112	96	84	74	67
24 W.G.	$13\frac{1}{4}$	16	$18\frac{3}{4}$	$21\frac{1}{4}$	24	$26\frac{3}{4}$	168	140	120	105	93	84
26 W.G.	$10\frac{1}{4}$	$12\frac{1}{2}$	$14\frac{1}{2}$	$16\frac{1}{2}$	$18\frac{3}{4}$	$20\frac{3}{4}$	216	180	154	135	120	108
28 W.G.	$9\frac{1}{4}$	$11\frac{1}{4}$	13	15	$16\frac{3}{4}$	$18\frac{3}{4}$	240	200	171	150	133	120

Cast-iron Soil Pipes with Socket Joints

Internal diameter in inches	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	6
Average weight per 6-ft. length in lb.—								
Medium strength	20	20	32	38	44	54	60	84
Heavy „	26 and 29	33	40 and 43	48	54	64	70	92
London County Council's requirements	—	—	—	48	54	—	69	84
Thickness of metal in inches ...	—	—	—	$\frac{3}{16}$	$\frac{3}{16}$	—	$\frac{1}{4}$	$\frac{1}{4}$

Cast-iron Drain Pipes with Socket Joints

(L.C.C. Requirements)

Internal diameter in inches	3	4	5	6
Thickness of metal in inches	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$
Weight per 9-ft. length in pounds, not less than ...	110	160	190	230

A 9-ft. length of 9-in. cast-iron pipe, with $\frac{1}{2}$-in. metal and socket joint, weighs about 420 lb.

HIGHEST AND LOWEST MONTHLY PRICES OF TIN, COPPER, ZINC, AND LEAD for 1906 and 1907

Block-tin Pipe

$\frac{1}{4}$ in. ...	... 7 and 9 oz. per yard.	$\frac{5}{8}$ in. ...	... 23 oz. per yard.
$\frac{5}{16}$ in. ...	... 9 and $11\frac{1}{2}$,, ,,	$\frac{3}{4}$ in. ...	... 30 ,, ,,
$\frac{3}{8}$ in. ...	... 11 and 13 ,, ,,	$\frac{7}{8}$ in. ...	... 38 ,, ,,
$\frac{7}{16}$ in. ...	... 14 ,, ,,	1 in. ...	... 48 ,, ,,
$\frac{1}{2}$ in. ...	... 17 ,, ,,		

Lead-encased Block-tin Pipe

$\frac{3}{8}$ in. ...	... $2\frac{1}{2}$, 3, and $3\frac{1}{2}$ lb. per yard.	1 in. ...	7, 8, 9, and 10 lb. per yard.
$\frac{1}{2}$ in. ...	... $3\frac{1}{2}$, 4, and $4\frac{1}{2}$,, ,,	$1\frac{1}{4}$ in. ...	... 9, 10, and 12 ,, ,,
$\frac{9}{16}$ in. ...	... $3\frac{1}{2}$ and $4\frac{1}{2}$,, ,,	$1\frac{1}{2}$ in.	11, $12\frac{1}{2}$, 14, and 16 ,, ,,
$\frac{5}{8}$ in. ...	$4\frac{1}{2}$, $5\frac{1}{4}$, $5\frac{1}{2}$, and 6 ,, ,,	$1\frac{3}{4}$ in. ...	... 17 and 24 ,, ,,
$\frac{3}{4}$ in. ...	$5\frac{1}{2}$, 6, 7, and 8 ,, ,,	2 in.	16, 18, 21, and 28 ,, ,,

Other sizes and lengths can also be made.

Weight of One Square Foot of Metals and Alloys.[1]

Thickness.	Wrought Iron.	Cast Iron.	Steel.	Copper.	Tin.	Zinc.	Brass.	Gun Metal.	Lead.
in.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
$\frac{1}{16}$	2·50	2·34	2·55	2·89	2·41	2·28	2·63	2·73	3·71
$\frac{1}{8}$	5·00	4·69	5·10	5·79	4·81	4·55	5·26	5·46	7·41
$\frac{3}{16}$	7·50	7·03	7·65	8·68	7·22	6·83	7·89	8·19	11·1
$\frac{1}{4}$	10·0	9·38	10·2	11·6	9·63	9·10	10·5	10·9	14·8
$\frac{5}{16}$	12·5	11·7	12·8	14·5	12·0	11·4	13·2	13·7	18·5
$\frac{3}{8}$	15·0	14·1	15·3	17·4	14·4	13·7	15·8	16·4	22·2
$\frac{7}{16}$	17·5	16·4	17·9	20·3	16·8	15·9	18·4	19·1	25·9
$\frac{1}{2}$	20·0	18·7	20·4	23·2	19·3	18·2	21·1	21·9	29·7

[1] From *The "Practical Engineer" Pocket-book.* The weights given in this table do not tally exactly in all cases with those given in the table taken from *Molesworth's Pocket-book.*

Weight and Specific Gravity of Metals and Alloys.[1]

	Weight of 1 Cubic Foot.	Specific Gravity.
Metals.	lb.	water = 1.
Aluminium, cast	159·8	2·56
„ sheet	166·6	2·67
Antimony, cast	419·5	6·72
Bismuth, „	613·1	9·822
Copper, cast	537·3	8·607
„ sheet	548·1	8·78
„ bolts	552·4	8·85
„ wire	555	8·9
Gold	1150	18·417
Iron, cast (average)	451	7·23
„ wrought (average)	485·6	7·78
Lead, cast	708·5	11·36
„ sheet	711·6	11·4
Mercury	848·75	13·596
Nickel *	548	8·8
Platinum	1343·9	21·531
„ sheet	1435·6	23
Silver	653·8	10·474
Steel	499	8
Tin, cast	455·1	7·291
Zinc, „	437	7
„ sheet *	449	7·2
Alloys.		
Aluminium bronze, 90 to 95 % copper	478·4	7·68
Bell-metal (small bells)	502·52	8·05
Brass, cast	524·37	8·4
„ sheet	526·86	8·44
„ wire	533·109	8·54
„ 4 copper to 1 zinc	527·36	8·448
„ 3 „ „ 1 „	524·18	8·397
„ 2 „ „ 1 „	518·06	8·299
„ 1 „ „ 1 „	513·75	8·23
„ 1 „ „ 4 „	460·13	7·371
Gun-metal, 10 copper to 1 tin	528·36	8·464
„ 9 „ „ 1 „	528·24	8·462
„ 8 „ „ 1 „	528·05	8·459
„ 7 „ „ 1 „	527·89	8·456
White metal (Babbett)	456·32	7·31

[1] From *Molesworth's Pocket-book*, except nickel and sheet zinc, marked *, which are taken from *The "Practical Engineer" Pocket-book.* The weight of a cubic foot of water, according to *Molesworth's Pocket-book*, is 62·425 lb., and the weight of a cubic foot of any metal or alloy can be found by multiplying its specific gravity by 62·425 lb. The weights and specific gravities given by different authorities vary to some extent, but the figures quoted above are usually regarded as sufficiently accurate for practical purposes.

APPENDIX III.—TABLES AND MENSURATION

A. WEIGHT

Avoirdupois Weight Table

16 drams	= 1 ounce (oz.)
16 ounces	= 1 pound (lb.)
28 pounds	= 1 quarter (qr.)
4 quarters or 112 pounds	= 1 hundredweight (cwt.)
20 hundredweight or 2240 pounds	= 1 ton

Metric Weight Table

10 milligrams (mg.)	= 1 centigram (cg.)
10 centigrams	= 1 decigram (dg.)
10 decigrams	= 1 gram (g. or gm.)
10 grams	= 1 decagram (Dg.)
10 decagrams	= 1 hectogram (hg.)
10 hectograms	= 1 kilogram (kg.)
10 kilograms	= 1 myriagram (Mg.)
10 myriagrams	= 1 quintal (ql.)
10 quintals	= 1 tonne (t.)

Conversion Table

To Convert	Into	Multiply by	Converse.
Milligrams	Grains	·015432	64·8
Centigrams	"	·154	6·48
Decigrams	"	1·543	·648
Grams	"	15·432	·0648
	Drams	·5644	1·772
	Ounces	·03527	28·350
Hectograms	"	3·527	·2835
Kilograms	Pounds	2·2046223	·45359243
	Cwts.	·01968	50·80
	Tons	·00984	1016

Note.—There are 7000 grains in 1 lb. avoirdupois. If it is required to convert (say) kilograms into pounds, multiply the number of kilograms by the figures in the third column on the same line as the word "Pounds",

namely, 2·2046223. It is obvious that 1 kg. = 2·204 lb., or rather more than $2\frac{1}{5}$ lb. Conversely, to convert lb. into kg., multiply the number of lb. by the figures in the fourth column on the same line, namely, ·45359243. 1 lb. = ·45359243 kg., or rather less than $\frac{1}{2}$ kg.

Avoirdupois Weight is the British standard weight for all plumbers' goods sold by weight, such as sheet lead.

Examples.—1. Convert 2115 lb. into cwt., qr., and lb. Divide first by 28, the number of lb. in 1 qr. The quotient will be the number of qr., and the remainder will be the number of lb. over. We thus find that in 2115 lb. there are 75 qr. and 15 lb.

Now divide the 75 qr. by 4, the number of qr. in 1 cwt. The quotient will be the number of cwt., and the remainder will be the number of qr. over.

```
28 ) 2115 ( 75
     196
     ----
      155
      140
      ---
       15
       ==

4 ) 75 qr. 15 lb.
   18 cwt. 3 qr. 15 lb.
```

2. Convert 18 cwt. 3 qr. 15 lb. into lb. Multiply the number of cwt. by 4 (the number of qr. in 1 cwt.), and add to the product the number of qr. in the given weight. Then multiply the sum thus obtained by 28 (the number of lb. in 1 qr.), and add the number of lb. in the given weight.

```
  18 cwt. 3 qr. 15 lb.
   4
  --
  72
   3 add
  --
  75
  28
 ---
 600
150
----
2100
  15 add
----
2115 lb.
```

3. Add the following: — First add together the figures in the lb. column. The sum is 99. Divide this by 28 (the number of lb. in 1 qr.). The quotient is 3 and the remainder 15. Place the remainder under the lb. column, and carry 3. Add this to the figures in the qr. column, and the sum is 11. Divide 11 by 4 (the number of qr. in 1 cwt.), and the quotient is 2 and the remainder 3. Place the remainder under the qr. column, and carry 2 to the cwt. column, and add. The sum is 18.

	cwt.	qr.	lb.
	1	1	9
	2	0	20
	5	3	13
	0	2	27
	6	1	19
	2	1	11
Total......	18	3	15

B. LENGTH

British Table of Linear Measure

	12	inches (in.)	= 1 foot (ft.)
	3	feet	= 1 yard (yd.)
	$5\frac{1}{2}$	yards	= 1 rod, or pole (po.)
	40	poles	= 1 furlong (fur.)
	8	furlongs or	= 1 mile (m.)
	1760	yards	
Also	100	links or	= 1 chain (ch.)
	22	yards	

Metric Table of Linear Measure

10 millimetres (mm.)	= 1 centimetre (cm.)
10 centimetres	= 1 decimetre (dm.)
10 decimetres	= 1 metre (m.)
10 metres	= 1 decametre (Dm.)
10 decametres	= 1 hectometre (hm.)
10 hectometres	= 1 kilometre (km.)
10 kilometres	= 1 myriametre (Mm.)

Conversion Table

To Convert	Into	Multiply by	Converse.
Millimetres	Inches	·03937	25·400
Centimetres	„	·3937	2·540
Decimetres	„	3·937	·254
Metres	Feet	3·280843	·3048
	Yards	1·0936143	·914399

Note.—This conversion table is used in the same way as that dealing with weights. 1 m. = 3·280843 ft., and 1 ft. = ·3048 m.

British Linear Measure is the standard measure for plumbers' goods sold by length, such as wrought-iron barrel, drain pipes, and soil pipes. In bills of quantities linear measurements are usually described as *lin. feet* or *feet run, lin. yds.* or *yds. run.*

Example. — 4. How many yards, feet, and inches are there in the following runs of pipe? First add together the figures in the in. column. The sum is 44. Divide this by 12 (the number of in. in 1 foot). The quotient is 3 and the remainder 8. Place the remainder under the in. column, and carry 3 to the ft. column, and add. The sum is 127. Divide 127 by 3 (the number of ft. in 1 yd.); the quotient is 42 and the remainder 1, and the answer is 42 yd. 1 ft. 8 in.

	ft.	in.
	24	6
	7	9
	4	11
	40	5
	12	3
	19	4
	18	6
3)	127	8
	42 yd. 1 ft. 8 in.	

C. AREA

British Table of Square Measure

144 square inches (sq. in.)	= 1 square foot (sq. ft.)
9 „ feet	= 1 square yard (sq. yd.)
30¼ „ yards	= 1 „ rod, square pole, or perch (per.)
40 perches	= 1 rood (ro.)
4 roods	= 1 acre (ac.)
640 acres	= 1 square mile (sq. m.)
Also 10 square chains or 4840 „ yards	= 1 acre

Metric Table of Square Measure

100 square millimetres ($mm.^2$)	=	1 square centimetre ($cm.^2$ or sq. cm.)
100 „ centimetres	=	1 „ decimetre ($dm.^2$ or sq. dm.)
100 „ decimetres	=	1 „ metre ($m.^2$ or sq. m.) or 1 centiare
10 centiares	=	1 deciare
10 deciares or 100 square metres	=	1 are or 1 square decametre
10 ares	=	1 decare
10 decares or 100 square decametres	=	1 hectare (ha.) or 1 square hectometre
100 „ hectometres	=	1 square kilometre ($km.^2$ or sq. km.)

Conversion Table

To Convert	Into	Multiply by	Converse.
Square millimetres	Square inches	·00155	645·16
„ centimetres	„ „	·15500	6·4516
„ decimetres	„ „	15·500	·064516
	„ feet	·10764	9·2903
„ metres	„ „	10·7639	·092903
	„ yards	1·1960	·836126

British Square Measure is the standard measure for goods sold by area, such as glass, and is used for obtaining the areas of sheet lead as a preliminary step in the calculation of the weight, and also for many other purposes in the trade.

According to the table there are 144 sq. in. in 1 sq. ft., but in practice it is usual to subdivide the foot *duodecimally*, *i.e.* into twelfths, thus—

1 foot	= 12 *primes*, and	1 sq. ft.	= 12 *superficial primes.*
1 prime	= 12 *seconds*, „	1 sup. prime	= 12 „ *seconds.*
1 second	= 12 *thirds*, „	1 „ second	= 12 „ *thirds.*

As a rule fractions of *inches run* are ignored, the next higher whole number being substituted; thus, $7\frac{1}{2}$ in. would be calculated as 8 in. It is therefore unnecessary to give examples containing fractions of inches. In linear measure an inch is $\frac{1}{12}$ of a foot, and therefore 1 inch = 1 prime or $1'$.[1]

Now it is obvious that (say) a square piece of lead measuring 1 ft. on each side contains exactly 1 sq. ft. or 144 sq. in., and that this can be cut into two equal pieces, each of which will measure 1 foot by 6 inches (or 1 ft. $\times$ $6'$) and will contain exactly $\frac{1}{2}$ sq. ft., or, according to the Table of Square Measure, $\frac{144}{2}$ = 72 sq. in. This is the number which will be obtained by reducing the two linear dimensions of each piece to inches, namely, 12 in. by 6 in., and multiplying them together, thus, 12 in. $\times$ 6 in. = 72 sq. in. The utility of duodecimals is that they allow calculations of square measure to be made without reducing the linear dimensions to

[1] It is customary in the building trades to use one accent for feet and two accents for inches; thus, 2 ft. 6 in. = $2'\ 6''$. But for the present it will be better to adopt the notification given in the text.

inches. The piece of lead, measuring 1 ft. by 6 in., would be calculated thus—

$$1 \text{ ft.} \times 6' = 6', \textit{i.e.}\ 6 \text{ superficial primes.}$$[1]

It is clear, therefore, that 6 superficial primes are equal to 72 sq. in. and that 1 sup. prime = 12 sq. in. By the definition, however, 1 sup. prime = 12 sup. seconds. Therefore 1 sq. in. = 1 sup. second. To convert feet into primes we multiply by 12, and to convert primes into seconds we multiply again by 12, and so on. Conversely, to convert seconds into primes, we divide by 12, and to convert primes into feet we divide again by 12.

Reverting to our example, we have

$$1 \text{ ft.} \times 6' = 6', \textit{i.e.}\ 6 \text{ sup. primes;}$$

or, as 1 ft. = 12 in., or (in linear measure) 12′ or 12 primes, we may express it thus—

$$12' \times 6' = 72'', \textit{i.e.}\ 72 \text{ sup. seconds,}$$
$$\text{and } 72'' \div 12 = 6', \textit{i.e.}\ 6 \text{ sup. primes.}$$

The points to be noted are that when a ft. and a prime are multiplied together, the product is in superficial primes, and that when two primes are multiplied together, the product is in superficial seconds. We may add that when a foot and a second are multiplied together, the product is in superficial seconds.

Suppose, now, that we cut off exactly one-fourth of our piece of lead, that is to say, a piece measuring 6 in. × 3 in., and containing, therefore, 18 sq. in., *i.e.* 18 sup. seconds. Dividing 18 by 12, we obtain a quotient of 1 and a remainder of 6, and express it by duodecimals thus—

$$6' \times 3' = \tfrac{18}{12}'' = 1'\ 6'', \textit{i.e.}\ 1 \text{ sup. prime and } 6 \text{ sup. seconds.}$$

Examples. — 5. Find the area of a square sheet of glass measuring 2 ft. 6′ × 2 ft. 6′.

Multiplying first by 2 ft., we have 6′ × 2 ft. = 12′, and dividing this by 12 we obtain 1 sq. ft.[2]

Next multiply 2 ft. × 2 ft., and the product is 4 sq. ft.

Then, 6′ × 6′ = 36″ = 3′.

Finally, 2 ft. × 6′ = 12′ = 1 sq. ft.

On adding these figures, we find that the area is 6 sq. ft. and 3 sup. primes.

ft.	′
2	6
2	6
1	0
4	0
1	3
6	3

6. Find the area and weight of a sheet of lead measuring 22 ft. 6 in. by 7 ft. 9 in., and weighing 6 lb. per sq. ft.

The steps are as follows:—

6′ × 7 ft. = 42′ = 3 sq. ft. (carried forward) and 6′;

22 ft. × 7 ft. = 154 sq. ft., to which we add 3 brought forward;

6′ × 9′ = 54″ = 4′ (carried forward) and 6″;

22 ft. × 9′ = 198′ = 16 sq. ft. 6′, to which we add 4′ brought forward.

ft.	′	″
22	6	0
7	9	0
157	6	0
16	10	6
174	4	6

) 202
16 10

[1] In the building trade primes are invariably known as *inches*, and this practice is somewhat confusing to the boy fresh from school.

[2] In actual work, this would be carried forward mentally and added to the 4 found by the next step, and the sum (*i.e.* 5) would be entered in the working out.

The area is 174 sq. ft. 4 sup. primes and 6 sup. seconds. To find the weight we must multiply by 6 lb., the weight per sq. ft.

ft.	′	″	
174	4	6	
6	0	0	
28) 1046	3	0	(37 qr. 11 lb. = 9 cwt. 1 qr. 11 lb.
84			
206			
196			
$10\frac{3}{12}$ = (say) 11.			

The steps are as follows:—

6″ × 6 lb. = 36″ lb. = 3′ (carried forward) and 0 remainder;
4′ × 6 lb. = 24′, to which must be added 3′ brought forward, making 27′ = 2 lb. (carried forward) and 3′ remainder;
174 × 6 lb. = 1044 lb., to which we add 2 lb. brought forward.

Divide by 28 to convert the lb. into qr., and by 4 to convert the qr. into cwt., and the answer is obtained—9 cwt. 1 qr. 11 lb. nearly.

7. Add the following areas, and find the number of sq. yd.

The seconds column is first added and divided by 12, the remainder 10 being set down as shown, and the quotient 2 carried forward to the primes column; the sum in this case is treated in the same way. On completing the addition, we divide the number of sq. ft. by 9 (the number of sq. ft. in 1 sq. yd.) to obtain the number of sq. yd.

ft.	′	″
12	8	3
6	2	5
7	6	0
41	8	9
13	11	10
12	9	7
9) 94	10	10
10 sq. yd. 5 sq. ft. nearly.		

Mensuration of Plane Figures.—In the plumber's business the calculation of the areas of various plane figures is often required, including squares and other rectangles, parallelograms and other four-sided figures, triangles, polygons or many-sided figures, and circles.

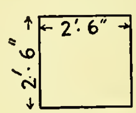
I. *To find the area of a rectangle.*

Rule.—Multiply the length by the breadth.

A rectangle is a four-sided figure, each of the four angles of which is a right angle. The simplest rectangle is a square.

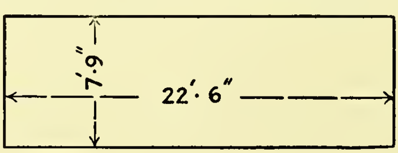
Examples.—8. Find the area of a piece of glass 2 ft. 6 in. square.

2 ft. 6′ × 2 ft. 6′ = 6 ft. 3′. (See Example 5, page 383.)



9. Find the area of a rectangular sheet of lead 22 ft. 6 in. long and 7 ft. 9 in. broad.

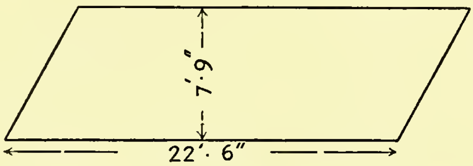
22 ft. 6′ × 7 ft. 9′ = 174 ft. 4′ 6″. (See Example 6, page 383.)



II. *To find the area of a parallelogram.*

Rule.—Multiply the base by the perpendicular height.

A parallelogram is a four-sided figure, the opposite sides of which are equal and parallel to each other. The opposite angles are also equal to each other, but two of the angles are greater than a right angle, and two are less.



Example.—10. Find the area of a parallelogram having a base measuring 22 ft. 6 in. and a perpendicular height measuring 7 ft. 9 in.

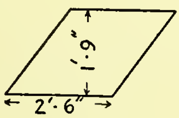
22 ft. 6′ × 7 ft. 9′ = 174 ft. 4′ 6″. (See Examples 6 and 9.)

III. *To find the area of a rhombus.*

Rules.—1. Multiply the base by the perpendicular height.
2. Multiply the diagonals together, and divide the product by 2.

A rhombus is a parallelogram with four equal sides.

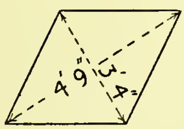
Examples.—11. Find the area of a diamond-shaped sheet of glass, having four equal sides 2 ft. 6 in. long and a perpendicular height of 1 ft. 9 in.



$$\begin{array}{rrr} \text{ft.} & ' & \\ 2 & 6 & \\ 1 & 9 & \\ \hline 2 & 6 & \\ 1 & 10 & 6'' \\ \hline 4 & 4 & 6 \\ \hline\hline \end{array}$$

2 ft. 6′ × 1 ft. 9′ = 4 ft. 4½′.

12. Find the area of a rhombus, the diagonals of which measure 4 ft. 9 in. and 3 ft. 4 in. respectively.



$$\begin{array}{rrr} & \text{ft.} & ' \\ & 4 & 9 \\ & 3 & 4 \\ \hline & 14 & 3 \\ & 1 & 7 \\ 2) & 15 & 10 \\ \hline & 7 & 11 \\ \hline\hline \end{array}$$

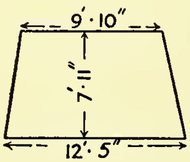
$$\frac{4 \text{ ft. } 9' \times 3 \text{ ft. } 4'}{2} = \frac{15 \text{ ft. } 10'}{2} = 7 \text{ ft. } 11'.$$

IV. *To find the area of a trapezoid.*

Rule.—Multiply half the sum of the parallel sides by the perpendicular distance between them.

A trapezoid is a four-sided figure having two sides parallel to each other, but of unequal length.

Example.—13. Find the area of a trapezoid, of which the two parallel sides are 9 ft. 10 in. and 12 ft. 5 in. in length respectively, and the perpendicular distance between them 7 ft. 11 in.



	ft.	′			
	9	10			
	12	5	add		
2)	22	3			
	11	1	6″		
	7	11			
	77	10	6		
	10	2	4	6	
	88	0	10	6	

$$\frac{9 \text{ ft. } 10' + 12 \text{ ft. } 5'}{2} \times 7 \text{ ft. } 11' = 11 \text{ ft. } 1'\ 6'' \times 7 \text{ ft. } 11'' = 88 \text{ ft. } 1' \text{ nearly.}$$

V. *To find the area of a triangle.*

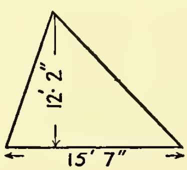
Rules.—1. Multiply the base by half the perpendicular height.

2. If the sides are given, multiply half the sum of the three sides by the product of the three remainders obtained by subtracting each of the sides from half the sum of the three sides, and extract the square root of the final product.

3. If the triangle is equilateral, *i.e.* if the sides are equal to each other, Rule 2 can be simplified as follows:—(*a*) Square the square of half a side, multiply by three, and extract the square root of the product; or further, (*b*) multiply the square of half a side by the square root of 3 (that is to say, by 1·73205).

Note.—The square of a number is the product obtained by multiplying the number by itself; thus, $5^2 = 25$. The squaring of the square would in this case be $5^2 \times 5^2 = 25 \times 25 = 625$, and would be expressed thus, $5^4 = 625$.

Examples.—14. Find the area of a triangle with a base of 15 ft. 7 in. and a height of 12 ft. 2 in.



	ft.	in.	
2)	12	2	
	6	1	
	15	7	
	91	3	
	3	6	7
	94	9	7

$$15 \text{ ft. } 7' \times \frac{12 \text{ ft. } 2'}{2} = 15 \text{ ft. } 7' \times 6 \text{ ft. } 1' = 94 \text{ ft. } 10' \text{ nearly.}$$

15. Find the area of a triangle, the sides of which measure 15 ft. 6 in., 12 ft. 9 in., and 10 ft. 5 in.

	ft.	′
	15	6
	12	9
	10	5
2)	38	8
	19	4

Half the sum of the three sides = 19 ft. 4 in.
The three remainders required by Rule 2 are—
(1) 19 ft. 4 in. − 15 ft. 6 in. = 3 ft. 10 in.
(2) 19 ft. 4 in. − 12 ft. 9 in. = 6 ft. 7 in.
(3) 19 ft. 4 in. − 10 ft. 5 in. = 8 ft. 11 in.

Then, the area = $\sqrt{19 \text{ ft. } 4 \text{ in.} \times 3 \text{ ft. } 10 \text{ in.} \times 6 \text{ ft. } 7 \text{ in.} \times 8 \text{ ft. } 11 \text{ in.}}$

Three methods of obtaining the product of these four measurements are available, namely, (1) by duodecimals; (2) by converting the dimensions into inches, and proceeding by simple multiplication; and (3) by vulgar fractions. We will adopt the last method. 4 in. = $\frac{4}{12}$ ft. = $\frac{1}{3}$ ft.; 10 in. = $\frac{10}{12}$ ft. = $\frac{5}{6}$ ft.; 7 in. = $\frac{7}{12}$ ft.; and 11 in. = $\frac{11}{12}$ ft.

Therefore, 19 ft. 4 in. = $19\frac{1}{3}$ ft., and this can be expressed more simply as $\frac{58}{3}$, which is obtained by multiplying the whole number (19) by the denominator of the fraction (namely, 3), and adding to the product the numerator of the fraction (namely, 1); the sum thus obtained (namely, 58), becomes the numerator of the fraction, the denominator being 3. In a similar manner—

3 ft. 10 in. = $3\frac{5}{6}$ ft. = $\frac{23}{6}$ ft.,
6 ft. 7 in. = $6\frac{7}{12}$ ft. = $\frac{79}{12}$ ft., and
8 ft. 11 in. = $8\frac{11}{12}$ ft. = $\frac{107}{12}$ ft.

Therefore, the area = $\sqrt{\frac{58}{3} \times \frac{23}{6} \times \frac{79}{12} \times \frac{107}{12}}$.

By dividing one numerator and one denominator by 2, we simplify this a little. We then multiply all the numerators together and all the denominators together, and divide the product of the numerators by the product of the denominators, thus—

$$\text{Area} = \sqrt{\frac{29}{3} \times \frac{23}{3} \times \frac{79}{12} \times \frac{107}{12}} = \sqrt{\frac{6038151}{1296}} = \sqrt{4659{\cdot}0671}.$$

To extract the square root of 4659·0671, write the figures down, and place a dot over the unit of the whole number—in this case, 9—and place other dots over the alternate figures to the right and left.

6	$\dot{4}6\dot{5}9{\cdot}\dot{0}6\dot{7}1$ (68·25
	36
128	1059
	1024
1362	3506
	2724
13645	78271
	68225
	10046

The figures up to the left-hand dot must first be considered, namely, 46. What whole number when multiplied by itself yields a product equal to or only a little less than 46? It is an easy matter to answer this question mentally; thus, we might say 5 × 5 = 25, 6 × 6 = 36, and 7 × 7 = 49. 7 is out of the question, as its square (49) is more than 46. 5 is also out of the question, as its square (25) does not approach 46 as nearly as does the square of 6. We therefore select 6 and place it on the divisor side and also on the quotient side as shown, multiply it by itself and place the product 36 under the figures 46. Subtract 36 from 46, and bring down the next two figures 59. Now multiply the first figure in the square root or quotient (6) by 2, and place the product 12 to the left of the figures 1059 as shown. How many times will 12 go into 105? The answer

is 8. Write 8 after the 6 in the square root and also after the 12 in the divisor column. Multiply 128 by 8, and place the product under the 1059 as shown, subtract, and bring down the next two figures. For the new divisor multiply 68 by 2, and place the product 136 as shown. 136 will go twice into 350. Therefore, the figure 2 must be added to the divisor and also to the root or quotient, but as the last two figures brought down in the dividend came after the decimal point, the figure 2 must be placed after a decimal point in the root. In the example the root is extracted to two places of decimals, and the area of the triangle is shown to be 68·25 sq. ft.

To convert the decimals into a fraction, place the figures 25 as the numerator, and 1 followed in this case by two noughts (because there are two places of decimals) as the denominator, thus, $\frac{25}{100}$. Dividing the numerator and denominator by 25, we have $\frac{25}{100} = \frac{1}{4}$. Therefore 68·25 sq. ft. = $68\frac{1}{4}$ sq. ft.

To convert the decimals into superficial primes, multiply by 12 and divide the product by 100, thus: $\frac{25 \times 12}{100} = 3$ sup. primes.

Therefore, 68·25 sq. ft. = 68 sq. ft. 3′.

It is clear that in many cases this is a laborious method of obtaining the area of a triangle. Rule 1 is a simpler method, and it is therefore better in taking measurements to measure the base and perpendicular.

16. Find the area of an equilateral triangle, the length of each side being 12 ft.

Half the length of the side is therefore 6 ft., and by Rule 3 (*a*).

$$\text{Area} = \sqrt{3 \times 6^2 \times 6^2} = \sqrt{3 \times 36 \times 36} = \sqrt{3888} = 62{\cdot}35 \ldots \text{sq. ft.}$$

$$\begin{array}{r|l}
 & 3\dot{8}8\dot{8}\ (62{\cdot}35 \\
 & 36 \\
\hline
122 & \ 288 \\
 & \ \underline{244} \\
1243 & \quad 4400 \\
 & \quad \underline{3729} \\
12465 & \qquad 67100 \\
 & \qquad \underline{62325} \\
 & \qquad\ \ 4775
\end{array}$$

By Rule 3 (*b*), area = $6^2 \times 1{\cdot}73205 = 62{\cdot}3538$ sq. ft.

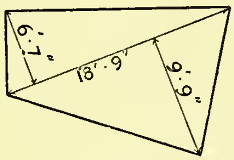
VI. *To find the area of a trapezium.*

Rule.—Divide the trapezium into two triangles by drawing one of the diagonals. The area of the trapezium is the sum of the areas of the two triangles.

A trapezium is a four-sided plane figure, the opposite sides of which are not parallel to each other.

As each triangle has the same base, the areas of the two may be calculated at one operation by multiplying the length of the diagonal by half the sum of the two perpendicular heights.

Example.—17. Find the area of a trapezium, of which one diagonal measures 18 ft. 9 in., and the two perpendicular heights measure 9 ft. 9 in. and 6 ft. 7 in. respectively.



	ft.	′		
	9	9		
	6	7		add
2)	16	4		
	8	2		
	18	9		
	147	0		
	6	1	6	
	153	1	6	

$$18 \text{ ft. } 9' \times \frac{9 \text{ ft. } 9' + 6 \text{ ft. } 7'}{2} = 18 \text{ ft. } 9' \times 8 \text{ ft. } 2' = 153 \text{ ft. } 1\tfrac{1}{2}'.$$

VII. *To find the area of a regular polygon.*[1]

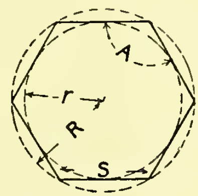
Rule.—Multiply the radius of the inscribed circle by half the number of sides, and multiply the product by the length of one side.

A regular polygon is a plane figure with five or more equal sides and equal angles.

The following table will be useful in this connection, and also for the purpose of drawing regular polygons with five, six, eight, ten, and twelve sides.

TABLE OF POLYGONS

A = Angle formed by the intersection of two adjacent sides,
R = Radius of circumscribed circle,
r = „ „ inscribed circle,
S = Side of polygon.



Name.	No. of Sides.	A.	Area = S² ×	S = R × and R = S ÷	S = r × and r = S ÷
Pentagon	5	108°	1·7205	1·1755	1·4536
Hexagon	6	120°	2·5980	1·0000	1·1547
Octagon	8	135°	4·8284	·7653	·8284
Decagon	10	144°	7·6942	·6180	·6498
Duodecagon	12	150°	11·1961	·5176	·5359

Examples.—18. Find the area of a regular pentagon having sides measuring 6 ft. 9 in. each.

Proceeding by the rule, we must first find the radius of the inscribed circle. This can be obtained graphically after the manner shown in the illustration of the hexagon above, or can be calculated from the length of the side by means

[1] The areas of irregular polygons can most easily be ascertained by dividing them into simpler figures, and taking suitable measurements either from the object itself or from a careful drawing to scale; thus, an irregular pentagon can be divided into a trapezium and a triangle, a hexagon into two trapeziums, and so on.

of the divisor in the last column of the Table of Polygons, where we find that $r = S \div 1{\cdot}4536$.

$$r = \frac{6 \text{ ft. } 9'}{1{\cdot}4536} = \frac{81'}{1{\cdot}4536} = 55{\cdot}72'.$$

$$\begin{array}{r}
1{\cdot}4536\,)\,81{\cdot}0000\,(\,55{\cdot}72 \\
72680 \\ \hline
83200 \\
72680 \\ \hline
10520 \\
101752 \\ \hline
3448
\end{array}$$

$$\begin{aligned}
\text{Area} &= 55{\cdot}72' \times \tfrac{5}{2} \times 6 \text{ ft. } 9'. \\
&= 139{\cdot}3' \times 6 \text{ ft. } 9' = 11 \text{ ft. } 7'\ 4'' \times 6 \text{ ft. } 9' \\
&= 78 \text{ ft. } 4\tfrac{1}{2}'.
\end{aligned}$$

$$\begin{array}{rrr}
\text{ft.} & ' & '' \\
11 & 7 & 4 \\
6 & 9 & \\ \hline
69 & 8 & \\
8 & 8 & 6 \\ \hline
78 & 4 & 6
\end{array}$$

19. By using the polygon tables the area can be calculated directly from the length of the side. Taking the same example as before, we have—

$$\text{Area} = S^2 \times 1{\cdot}7205 = 6 \text{ ft. } 9' \times 6 \text{ ft. } 9' \times 1{\cdot}7205.$$

The simplest method of working this out will be to reduce one 6 ft. 9′ to primes, multiply these by 1·72 (the two last places of decimals being neglected), and convert the product back to feet, primes, and seconds.

$$\begin{array}{r}
\text{ft.}\ \ ' \\
6\ \ 9 \\
12\ \ \ \\ \hline
81 \\
1{\cdot}72 \\ \hline
1\,62 \\
56\,7\ \ \\
81\ \ \ \ \\ \hline
12\,)\,139{\cdot}32
\end{array}$$

$$6 \text{ ft. } 9' \times 1{\cdot}72 = 11 \text{ ft. } 7'\ 4''.$$

$$6 \text{ ft. } 9' \times 6 \text{ ft. } 9' \times 1{\cdot}72 = 6 \text{ ft. } 9' \times 11 \text{ ft. } 7'\ 4'' = 78 \text{ ft. } 4\tfrac{1}{2}'.$$

The last step is the same as in Example 18.

VIII. *To find the area of a circle.*

Rules.—1. Multiply the square of the diameter by ·7854 $\left(\text{or } \frac{\pi}{4}\right)$.

2. „ „ „ radius by 3·1416 (or π).
3. „ „ „ circumference by ·08.
4. „ the circumference by half the radius.

These four rules, or modifications of the same rule, are based on the fact that the circumference of any circle bears a constant ratio to its diameter; this ratio is denoted by the symbol π, and is 3·1416, or approximately $\frac{22}{7}$ or $3\frac{1}{7}$. In other words, if the diameter of a circle is multiplied by 3·1416, the product will be the circumference of the circle; and if the circumference is divided by 3·1416, the quotient will be the diameter. As the diameter of a circle is twice the radius, the second rule follows from the first, thus—

$$d^2 \times {\cdot}7854 = (2r)^2 \times {\cdot}7854 = 4 \times r^2 \times {\cdot}7854 = r^2 \times 3{\cdot}1416.$$

Example.—20. Find the area of a circle 5 ft. 6 in. in diameter. Rule 2 is the simplest for general purposes, and will be adopted.

The radius in this case will be $\frac{5 \text{ ft. } 6'}{2} = 2 \text{ ft. } 9'$.

$$2 \text{ ft. } 9' \times 2 \text{ ft. } 9' \times \tfrac{22}{7} =$$
$$7 \text{ ft. } 6' \, 9'' \times 3\tfrac{1}{7} = 23 \text{ ft. } 9\tfrac{1}{4}' \text{ nearly.}$$

ft.	′	
2	9	
2	9	
5	6	
2	0	9
7	6	9
$3\frac{1}{7}$		
22	8	3
1	0	$11\frac{4}{7}$
23	9	$2\frac{4}{7}$

The only step to which attention need be drawn is the multiplication of 7 ft. 6′ 9″ by $3\frac{1}{7}$. Multiply first by 3. Then divide 7 ft. 6′ 9″ by 7 in three stages, thus: (1) divide 7 ft. by 7, and place the quotient 1 under the 22 ft. below; there is no remainder to carry forward; (2) divide 6′ by 7; the quotient is 0 and is placed under the 8′ below, and the remainder 6′ is carried forward and multiplied by 12 to convert it into seconds and the product is added to the 9″, giving a total of 72 + 9 = 81″; (3) divide 81″ by 7, and place the quotient and fraction under the 3″ below.

The following tables, containing the areas of circles up to 50 in. in diameter, will be useful, and may be extended almost indefinitely, with sufficient accuracy for ordinary purposes, by the simple rule that the areas of circles vary directly as the squares of their diameters. Thus, if the diameter of a circle A is twice the diameter of a circle B, the area of A will be (2 × 2 =) 4 times the area of B; if the diameter of a circle C is three times that of a circle D, the area of C will be (3 × 3 =) 9 times the area of D.

Example.—21. What is the area of a circle 16 ft. 7 in. in diameter?

One-fourth of 16 ft. 7 in. is 4 ft. $1\frac{3}{4}$ in. = $49\frac{3}{4}$ in.

The area of a circle $49\frac{3}{4}$ in. in diameter is, according to the table, 1943·9 sq. in.

Therefore, the area of a circle 16 ft. 7 in. in diameter is

$$1943{\cdot}9 \text{ sq. in.} \times 4 \times 4 = 31102{\cdot}4 \text{ sq. in.}$$
$$= \frac{31102{\cdot}4}{144} \text{ sq. ft.} = 215{\cdot}98 \text{ sq. ft.}$$

A close approximation to this can be obtained directly by regarding the diameters and areas in the table as being in feet. Thus, the area of a circle $16\frac{5}{8}$ ft. in diameter is 217 sq. ft., while the area of a circle $16\frac{1}{2}$ ft. in diameter is 213·8 sq. ft., the difference between the two being 3·2 sq. ft. Now the difference between $16\frac{1}{2}$ ft. and 16 ft. 7 in. is 1 in., and that between 16 ft. 7 in. and $16\frac{5}{8}$ ft. is $\frac{1}{2}$ in., the difference between $16\frac{1}{2}$ ft. and $16\frac{5}{8}$ ft. being $1\frac{1}{2}$ in.

Adjusting these differences by simple proportion, we obtain $1\frac{1}{2} : \frac{1}{2} :: 3{\cdot}2 : 1{\cdot}06$.

Deducting 1·06 sq. ft. from 217 sq. ft., we obtain 215·94 sq. ft.

This is very nearly the same as the area obtained by the first and more accurate method.

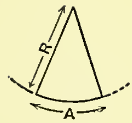
Table of Areas of Small Circles, with Diameters advancing by 32nds up to 1

Diameter.	Area.	Diameter.	Area.	Diameter.	Area.	Diameter.	Area.
$\frac{1}{32}$	·00077	$\frac{9}{32}$	·0621	$\frac{17}{32}$	·2217	$\frac{25}{32}$	·4794
$\frac{1}{16}$	·00307	$\frac{5}{16}$	·0767	$\frac{9}{16}$	·2485	$\frac{13}{16}$	·5185
$\frac{3}{32}$	·00690	$\frac{11}{32}$	·0928	$\frac{19}{32}$	·2769	$\frac{27}{32}$	·5591
$\frac{1}{8}$	·01227	$\frac{3}{8}$	·1104	$\frac{5}{8}$	·3068	$\frac{7}{8}$	·6013
$\frac{5}{32}$	·01917	$\frac{13}{32}$	·1296	$\frac{21}{32}$	·3382	$\frac{29}{32}$	·6450
$\frac{3}{16}$	·02761	$\frac{7}{16}$	·1503	$\frac{11}{16}$	·3712	$\frac{15}{16}$	·6903
$\frac{7}{32}$	·03760	$\frac{15}{32}$	·1726	$\frac{23}{32}$	·4057	$\frac{31}{32}$	·7371
$\frac{1}{4}$	·04909	$\frac{1}{2}$	·1963	$\frac{3}{4}$	·4418	1	·7854

Table of Areas of Circles, with Diameters advancing by 8ths

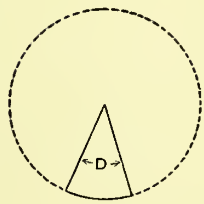
Diam.	Areas.								Diam.
	·0	$\cdot\frac{1}{8}$	$\cdot\frac{1}{4}$	$\cdot\frac{3}{8}$	$\cdot\frac{1}{2}$	$\cdot\frac{5}{8}$	$\cdot\frac{3}{4}$	$\cdot\frac{7}{8}$	
0	·0	·0122	·0490	·1104	·1963	·3068	·4417	·6013	0
1	·7854	·9940	1·227	1·484	1·767	2·073	2·405	2·761	1
2	3·142	3·546	3·976	4·430	4·908	5·411	5·939	6·491	2
3	7·069	7·669	8·295	8·946	9·621	10·32	11·04	11·79	3
4	12·57	13·36	14·18	15·03	15·90	16·80	17·72	18·66	4
5	19·64	20·62	21·64	22·69	23·75	24·85	25·96	27·10	5
6	28·27	29·46	30·67	31·91	33·18	34·47	35·78	37·12	6
7	38·48	39·87	41·28	42·71	44·17	45·66	47·17	48·70	7
8	50·27	51·84	53·45	55·08	56·74	58·42	60·13	61·86	8
9	63·62	65·39	67·20	69·02	70·88	72·75	74·66	76·58	9
10	78·54	80·51	82·51	84·54	86·59	88·66	90·76	92·88	10
11	95·03	97·20	99·40	101·6	103·8	106·1	108·4	110·7	11
12	113·1	115·4	117·8	120·2	122·7	125·1	127·6	130·1	12
13	132·7	135·2	137·8	140·5	143·1	145·8	148·4	151·2	13
14	153·9	156·6	159·4	162·2	165·1	167·9	170·8	173·7	14
15	176·7	179·6	182·6	185·6	188·6	191·7	194·8	197·9	15
16	201·1	204·2	207·3	210·5	213·8	217·0	220·3	223·6	16
17	227·0	230·3	233·7	237·1	240·5	243·9	247·4	250·9	17
18	254·4	258·0	261·5	265·1	268·8	272·4	276·1	279·8	18
19	283·5	287·2	291·0	294·8	298·6	302·4	306·3	310·2	19
20	314·1	318·1	322·0	326·0	330·0	334·1	338·1	342·2	20
21	346·4	350·4	354·6	358·8	363·0	367·2	371·5	375·8	21
22	380·1	384·4	388·8	393·2	397·6	402·0	406·4	410·9	22
23	415·5	420·0	424·5	429·1	433·7	438·3	443·0	447·6	23
24	452·4	457·1	461·8	466·6	471·4	476·2	481·1	485·9	24
25	490·9	495·7	500·7	505·7	510·7	515·7	520·7	525·8	25
26	530·9	536·0	541·1	546·3	551·5	556·7	562·0	567·2	26
27	572·6	577·8	583·2	588·5	593·9	599·3	604·8	610·2	27
28	615·8	621·2	626·7	632·3	637·9	643·5	649·1	654·8	28
29	660·5	666·2	671·9	677·7	683·4	689·2	695·1	700·9	29
30	706·9	712·7	718·6	724·6	730·6	736·6	742·6	748·6	30
31	754·8	760·9	767·0	773·1	779·3	785·5	791·7	798·0	31
32	804·2	810·5	816·9	823·2	829·6	836·0	842·4	848·8	32
33	855·3	861·8	868·3	874·8	881·4	888·0	894·6	901·3	33
34	907·9	914·6	921·3	928·1	934·8	941·6	948·4	955·3	34
35	962·1	969·0	975·9	982·8	989·8	996·8	1003·8	1010·8	35
36	1017·9	1025·0	1032·1	1039·2	1046·4	1053·5	1060·7	1068·0	36
37	1075·2	1082·5	1089·8	1097·1	1104·5	1111·8	1119·2	1126·7	37
38	1134·1	1141·6	1149·1	1156·6	1164·2	1171·7	1179·3	1186·9	38
39	1194·6	1202·3	1210·0	1217·7	1225·4	1233·2	1241·0	1248·8	39
40	1256·6	1264·5	1272·4	1280·3	1288·3	1296·2	1304·2	1312·2	40
41	1320·3	1328·3	1336·4	1344·5	1352·7	1360·8	1369·0	1377·2	41
42	1385·4	1393·7	1402·0	1410·3	1418·6	1427·0	1435·4	1443·8	42
43	1452·2	1460·7	1469·1	1477·6	1486·2	1494·7	1503·3	1511·9	43
44	1520·5	1529·2	1537·9	1546·6	1555·3	1564·0	1572·8	1581·6	44
45	1590·4	1599·3	1608·2	1617·0	1626·0	1634·9	1643·9	1652·9	45
46	1661·9	1671·0	1680·0	1689·1	1698·2	1707·4	1716·5	1725·7	46
47	1734·9	1744·2	1753·5	1762·7	1772·1	1781·4	1790·8	1800·1	47
48	1809·6	1819·0	1828·5	1837·9	1847·5	1857·0	1866·6	1876·1	48
49	1885·7	1895·4	1905·0	1914·7	1924·4	1934·2	1943·9	1953·7	49
50	1963·5	1973·3	1983·2	1993·1	2003·0	2012·9	2022·8	2032·8	50

IX. *To find the area of a sector of a circle*



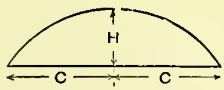
Rules.—1. Multiply the length of the arc by half the radius, *i.e.* Area $= A \times \frac{R}{2}$.

2. Multiply the number of degrees in the arc by the area of the circle of which the sector forms a part, and divide the product by 360, *i.e.* Area $= \frac{D \times \text{Area of circle}}{360}$.



A sector of a circle is that portion of a circle which is enclosed by two radii and the arc or portion of the circumference between the radii.

X. *To find the area of a segment of a circle.*

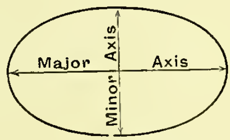


Rule.—Area $= \frac{4\,H}{3} \times \sqrt{(0{\cdot}626\,H)^2 + C^2}$.

A segment of a circle is that portion of a circle which is enclosed by part of the circumference of the circle and by a straight line or chord (CC) joining the ends of that part of the circumference.

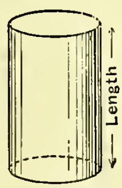
XI. *To find the area of an ellipse.*

Rule.—Multiply the major axis by the minor axis, and the product by ·7854.



The definition of an ellipse is not easily understood without explanation, but the rule given above applies only to true ellipses drawn with a trammel or similar instrument, and not to quasi-elliptical figures drawn with compasses from a number of different centres.

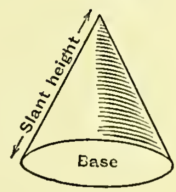
XII. *To find the area of the surface of a cylinder.*



Rule.—Multiply the length by the circumference, and add to the product the areas of the two ends.

The ends of a right cylinder are true circles, and are equal to each other. The area can be found by Rule VIII.

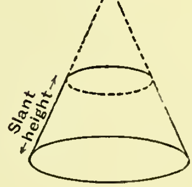
XIII. *To find the area of the surface of a cone.*



Rule.—Multiply the circumference of the base by half the slant height, and add to the product the area of the base.

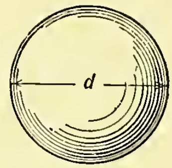
The base of a right cone is a circle, and the area of this can be found by Rule VIII.

XIV. *To find the area of the surface of a frustum.*



Rule.—Multiply the sum of the circumferences of the two ends by half the slant height, and add to the product the area of the two ends.

XV. *To find the area of the surface of a sphere.*



Rule.—Multiply the square of the diameter by 3·14159. The area of the surface of a sphere is therefore four times the area of a circle having the same diameter (see Rule VIII).

D. VOLUME

British Table of Cubic Measure

1728 cubic inches (cu. in.) = 1 **cubic foot** (cu. ft.)
27 ,, feet = 1 cubic yard (cu. yd.)

Metric Table of Cubic Measure

1000 cubic millimetres (mm.^{3}) = 1 cubic centimetre (cm.^{3} or c.c.)
1000 ,, centimetres = 1 ,, decimetre (dm.^{3})
1000 ,, decimetres or 10 decisteres } = 1 stere or 1 cubic metre (m.^{3} or cu.m.)
10 steres = 1 decastere

Conversion Table

To Convert	Into	Multiply by	Converse.
Cubic millimetres	Cubic inches	·000061	16387
,, centimetres	,, ,,	·0610	16·387
,, decimetres	,, ,,	61·024	·016387
,, metres	,, feet	35·3148	·028317
	,, yards	1·307954	·764553

British Cubic Measure is used by the plumber in calculating the contents of tanks, and for other purposes. As a rule, the vessels to be measured are either rectangular, as in the case of ordinary cisterns or tanks for water, or cylindrical, as in the case of pipes and hot-water cylinders.

XVI. *To find the cubical content of a rectangular vessel.*

Rule.—Multiply the length, breadth, and depth together.

Example.—22. Find the cubical content in feet and the capacity in gallons of a rectangular cistern measuring 6 ft. 6 in. by 3 ft. 8 in. by 3 ft. 6 in. inside.

The simplest method is that of duodecimals.

The cubical content is 83 cu. ft. 5′, *i.e.* $83\frac{5}{12}$ cu. ft.

A cubic foot of water contains very nearly $6\frac{1}{4}$ gallons, and this is usually considered sufficiently correct for practical purposes.

ft.	′	
6	6	length
3	8	breadth
19	6	
4	4	
23	10	
3	6	depth
71	6	
11	11	
83	5	

Therefore, $83\frac{5}{12} \times 6\frac{1}{4} = \frac{1001}{12} \times \frac{25}{4} = \frac{25025}{48} = 521·3$ gal.

If the cubical content and two of the dimensions of the tank are known, the third dimension can be calculated as follows:—

Length	=	cubical content	÷	(breadth	×	depth);
Breadth	=	„ „	÷	(length	×	depth);
Depth	=	„ „	÷	(length	×	breadth).

XVII. *To find the cubical content of a cylindrical vessel.*

Rule.—Multiply the area of one of the circular ends by the depth of the vessel. In the case of a pipe, the area of the bore must be multiplied by the length of the pipe.

Example.—23. Find the capacity in gallons of a hot-water cylinder 1 ft. 8 in. in diameter and 3 ft. 6 in. high.

According to the table on page 392, the area of a circle 20 in. in diameter is 314·1 sq. in. = 2·18 sq. ft.

In this case it is simpler to proceed by decimals, the height of 3 ft. 6 in. being altered to 3·5 ft.

$$\therefore\ 2{\cdot}18 \times 3{\cdot}5 = 7{\cdot}63 \text{ cu. ft.}$$
$$\text{and } 7{\cdot}63 \times 6{\cdot}22 \text{ gal.} = 47{\cdot}5 \text{ gal. or } 47\tfrac{1}{2} \text{ gal.}$$

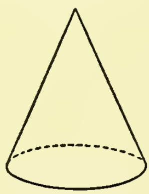
In this calculation no allowance has been made for the domed bottom and top, but the height given has been assumed to be the mean height.

XVIII. *To find the volume of a right cone or pyramid.*

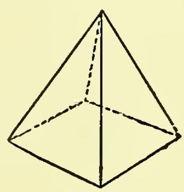
Rule.—Multiply the area of the base by one-third of the perpendicular height.

XIX. *To find the volume of a sphere.*

Rule.—Multiply the cube of the diameter by 0·5236.



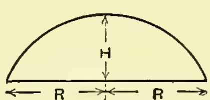
Cone



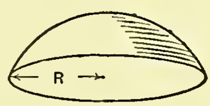
Pyramid

XX. *To find the volume of a segment of a sphere.*

Rule.—Multiply the height of the segment by 0·5236, and multiply the product by the sum of the square of the height and three times the square of the radius of the base; that is to say, volume = 0·5236 H ($H^2 + 3R^2$).



Section



View

E. CAPACITY

British Table of Liquid Measure

4 gills	=	1 pint (pt.)
2 pints	=	1 quart (qt.)
4 quarts	=	1 gallon (gal.)
36 gallons	=	1 barrel

British Table of Dry or Corn Measure

2 gallons = 1 peck (pk.)
4 pecks = 1 bushel (bush.)
8 bushels = 1 quarter (qr.)

Metric Table of Capacity

10 millilitres (ml.)	= 1 centilitre (cl.)
10 centilitres	= 1 decilitre (dl.)
10 decilitres or 1000 cubic centimetres	= 1 litre (l.)
10 litres	= 1 decalitre (Dl.)
10 decalitres	= 1 hectolitre (Hl.)
10 hectolitres	= 1 kilolitre (Kl.)

Conversion Table

To Convert	Into	Multiply by	Converse.
Decilitres	Gills	·70	1·42
	Pints	·176	5·682
Litres	"	1·75980	·5682
	Quarts	·880	1·136
	Gallons	·219975	4·5459631
Decalitres	"	2·19975	·4546
	Bushels	·275	3·637
Hectolitres	"	2·75	·3637
	Quarters	·34381	2·909
Kilolitres	Gallons	219·975	·004546
	Bushels	27·5	·03637
	Quarters	3·4381	·2909

The weight of a gallon of water is 10 lb., and of a cubic foot of water about 62¼ lb. The weight in lb. of the water contained in a tank can therefore be ascertained by multiplying the number of gallons by 10 or the number of cubic ft. by 62¼. Conversely, if the weight of the water in a vessel is known, the number of gallons can be ascertained by dividing the weight by 10, and the number of cubic ft. by dividing the weight by 62¼.

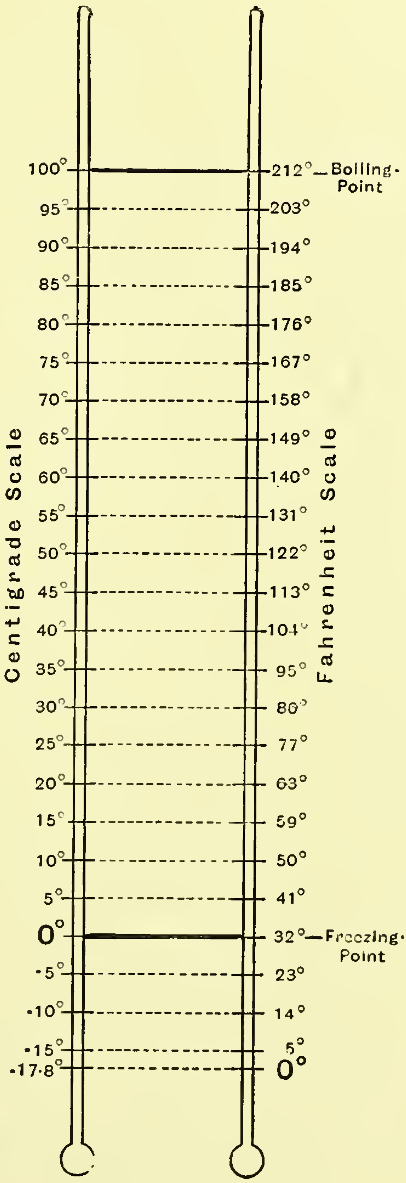
Dry or Corn Measure is still occasionally used in the building trade for the measurement of cement and sand. The usual measure is the bushel, but the peck is occasionally used. The weight of a bushel of cement varies according to the nature and condition of the cement, particularly the fineness of the particles. A finely-ground cement weighs less, measure for measure, than a coarse cement. The weight of a bushel of cement is seldom less than 100 lb. or more than 112 lb.

APPENDIX IV.—TEMPERATURE

The accompanying figure shows the relation of the Fahrenheit to the Centigrade thermometer. To transform a temperature from one scale to the other the following formulæ are required:—

$$C^\circ = \tfrac{5}{9}\,(F^\circ - 32),$$
$$F^\circ = \tfrac{9}{5}\,C^\circ + 32.$$

Temperatures below zero on either scale are denoted by the minus sign —. The Centigrade zero is the freezing-point, but the Fahrenheit zero is 32 Fahrenheit degrees (or 17·8 Centigrade degrees) below freezing-point. The temperature — 40° is the same on both scales.



Melting-points of Fusible Alloys[1]

Tin.	Lead.	Bismuth.	Melting-point Deg. F.
2	3	5	199
1	1	4	201
3	2	5	212
4	1	5	246
1	1	1	255
2	2	1	292
3	3	1	310
4	4	1	320
3	1	—	330
2	1	—	340
4	1	—	365
1	1	—	370
6	1	—	380
4	7	—	420
8	15	—	430
1	2	—	440
8	17	—	450
4	10	—	470
1	3	—	480
4	14	—	490
8	33	—	500
1	5	—	510
4	25	—	520
4	30	—	530
1	10	—	540
1	12	—	550
1	25	—	560

[1] From *The "Practical Engineer" Pocket-book*

Other authorities give different melting-points for some of the alloys of lead and tin; Hiorns, for example, in his book on *Mixed Metals*, quotes from Tilden's *Chem. Philosophy* the melting-points in degrees Centigrade given below:—

Tin.	Lead.	Melting-point.	
		Deg. C.	Deg. F.
1	4	292	557
1	3	283	541
1	2	270	518
1	1	235	455
2	1	197	386
3	1	181	357
3·3	1	180	356
4	1	187	368

Melting-points and Expansion of Metals [1]

Metals.	Melting-point.	Coefficient of Expansion.
	Deg. F.	Per deg. F.
Aluminium (pure)	1300	·00001235
Antimony	810	·00000601
Bismuth	507	·0000078
Brass	1650	·00001047
Copper	1996	·00000887
Gold	2166	·00000821
Iron (cast)	1920 to 2012	·00000616
Iron (wrought)	2912	·00000657
Lead	612	·00001555
Nickel	2810	·00000695
Platinum	3080	·00000493
Silver	1832	·00001063
Steel (hard)	2370	·00000695
Steel (mild)	2550	·00000672
Tin	446	·0000121
Zinc	736	·00001636

Sir W. C. Roberts-Austen, in his *Introduction to the Study of Metallurgy*, gives the following melting-points:—Aluminium, 649° C. (1560° F.); copper, 1083° C. (1981° F.); gold, 1063° C. (1945° F.); lead, 326° C. (618° F.); platinum, 1775° C. (3227° F.); silver, 960° C. (1760° F.); and zinc, 418° C. (784° F.).

[1] From *The "Practical Engineer" Pocket-book*

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